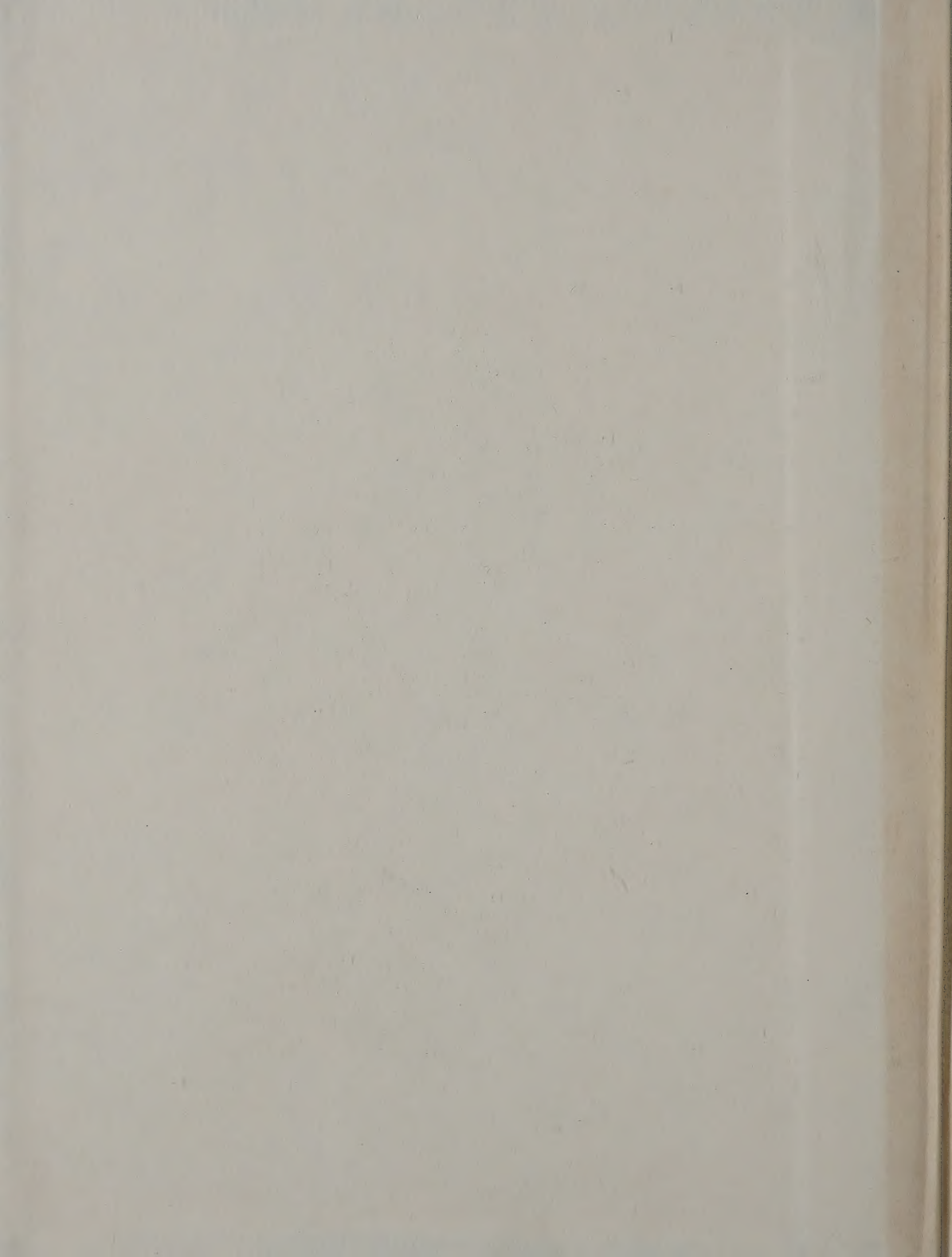




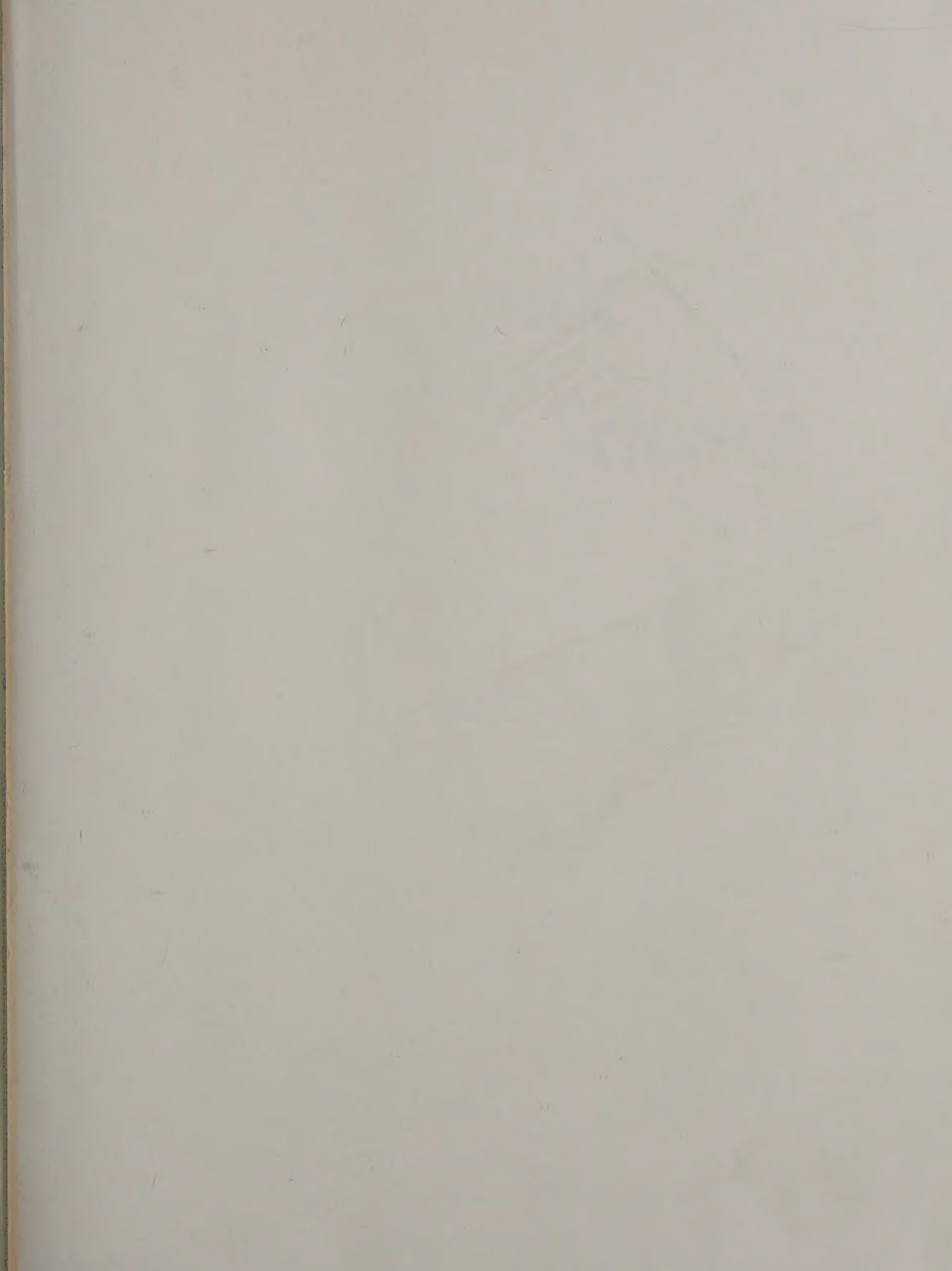
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The effect of extensive mesencephalic central gray lesions on responses to reinforcing brain stimulation¹

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Extensive central gray lesions did not interfere with septal self-stimulation behavior or escape responding to aversive dorsomedial tegmental stimulation.

Electrical stimulation of various neural sites may produce motivational consequences which result in appetitive (self-stimulation) or defensive (escape) behavior (Olds, 1962). The diversity of neural sites capable of producing motivated behavior has led to speculation about the way these sites are related. The possibility of some critical locus for these effects has prompted several investigators to examine the changes in responses to reinforcing brain stimulation following the production of brain lesions (Olds, 1964; Valenstein & Campbell, 1966; Ward, 1960, 1961). A relatively unexplored area, the mesencephalic central gray, is of particular interest because of its many connections with brain stem, limbic, and diencephalic structures including positive and negative reinforcing areas.

Central gray connections with positive reinforcing areas (the lateral and posterior hypothalamus and septum) and negatively reinforcing areas (the periventricular hypothalamic structures) have been described by Bucher & Burgi (1953), Cowan, Guillery, & Powell (1964), Guillery (1957), Morest (1961) and Nauta (1956, 1958, 1960). Connections with the lateral hypothalamus and septum are primarily via the medial forebrain bundle, mammillary peduncle, and mammillotegmental tract. The septal area is also connected to the central gray by way of the hippocampus and fornix fibers. Connections with the periventricular and posterior hypothalamic structures are via the dorsal longitudinal fasciculus.

The mesencephalic central gray itself may play an important role in the mediation of pain. Anatomical evidence in support of this view has been provided by Mehler (1962), and Mehler, Feferman, & Nauta (1960), who have described major fiber termination of the spinothalamic "pain tract" in the central gray. Behavioral studies have demonstrated the aversive properties of electrical stimulation of the central gray (Abrahams, Hilton, & Zbrozyna, 1960; Livingston, 1962; Olds & Olds, 1962; Olds & Peretz, 1960; Skultety, 1963; Spiegel, Kletzin, & Szekely, 1954; Valenstein, 1965; Wilkinson & Peele, 1963). Lesions in this area have been reported to decrease responsiveness to noxious peripheral stimuli (Melzack, Stotler, & Livingston, 1958; Skultety, 1958).

The present study reports the effects of extensive central gray lesions on septal self-stimulation and escape behavior from aversive dorsomedial tegmental stimulation posterior to the lesion site.

Method

Six male albino rats (300-400 gm) of the Holtzman strain were used. Two Ss were implanted with septal electrodes (Diagonal Band of Broca) and four Ss were implanted with dorsomedial tegmentum electrodes. With the skull level between the lambda and bregma, the tegmental electrodes were inserted at an angle of 25.5 degrees from the vertical, 7.0 mm posterior to the bregma, 2.5 mm lateral and 4.75 mm below the skull surface. All six Ss received bilateral electrolytic lesions of the mesencephalic central gray. The current used for lesions was 2.0 ma DC delivered for 20-25 sec. Following lesions and electrode implantation, the response of Ss to brain stimulation was evaluated. Self-stimulation was observed in a conventional lever pressing chamber. Lever presses were reinforced with a 0.5 sec. train duration of pairs of biphasic rectangular pulses (pulse duration 0.2 msec.; pulse pair frequency 100/sec.) delivered on a CRF schedule. After initial lever pressing training animals received five 24 min. tests. A test consisted of three 8 min. sessions each preceded by a 2 min. "warm-up" period. Current levels were 0.3, 0.65 and 1.0 ma for the three consecutive sessions. Lever pressing rates were recorded automatically. Escape behavior from continuous tegmental stimulation (current range 75-350 μ A) with the same parameters as described for the septal stimulation was observed in a two-compartment shuttlebox (60 by 25 cm and 42.5 cm high). Photo electric cell assemblies located 12.5 cm from each end of the box were used with appropriate circuitry to record escape responses.

Results and Discussion

Lesions in Ss with septal electrodes destroyed 90-100% of the central gray matter under the superior colliculi from the level of the Edinger-Westphal nucleus to the anterior margin of the inferior colliculi. Additional posterior damage spared the dorsal and deep tegmental nuclei, but destroyed central gray matter above and anterior to these nuclei. Figure 1 illustrates the destruction in one of these animals. Both septal animals lever pressed at rates comparable to or higher than that typically observed in unlesioned animals with similar electrode placements. Average response rates for the five

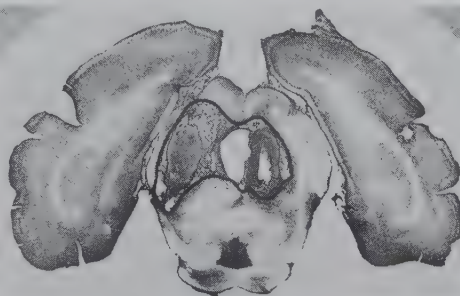


Fig. 1. Central gray damage in animal with reinforcing septal electrode.

tests were 70 and 95 responses per minute for the two Ss.

Three Ss with aversive dorsomedial tegmental electrodes suffered 90-100% destruction of the cross sectional extent of the central gray including the dorsal longitudinal fasciculus. The remaining S suffered 80% damage. The major destruction in all animals extended from the level of the commissure of the superior colliculi to the brachium of the inferior colliculus. Figure 2 illustrates the extent of central gray destruction in one of the three animals suffering the more extensive destruction. All four Ss escaped vigorously from dorsal central gray stimulation posterior to the lesion site. The escape latencies, which averaged less than 1.5 sec., were not different from those typically observed at comparable intensities in unlesioned animals with similar electrode placements.

It appears that extensive mesencephalic central gray lesions do not interfere with either septal self-stimulation or escape behavior from dorsomedial tegmental stimulation. Similar observations on escape behavior of cats has been reported by Skultety (1963). It is concluded that the aversive properties of dorsomedial tegmental stimulation and the positive properties of septal stimulation are not dependent upon the integrity of pathways such as the dorsal longitudinal fasciculus which traverse the rostral half of the central gray.

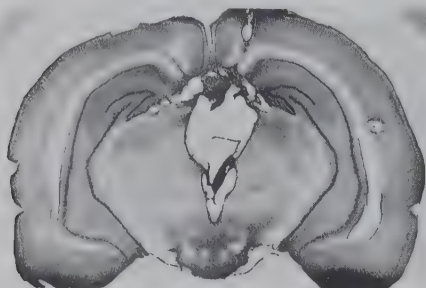


Fig. 2. Central gray damage in animal with aversive tegmental electrode.

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Maze preferences in naive rats produced by injection of ribonucleic acid from trained rats¹

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One group of rats was trained with food reward to choose alternative A in a two-choice discrimination apparatus, and a second group was trained to choose alternative B. Ribonucleic acid was extracted from the brains of these trained rats and was injected into untrained rats. On subsequent unreinforced test trials the untrained rats showed a significant tendency to choose the alternative to which their respective donor rats had been trained.

In two recent experiments (Babich, Jacobson, Bubash, & Jacobson, 1965; Jacobson, Babich, Bubash, & Jacobson, 1965), we found that when ribonucleic acid (RNA) from the brains of trained rats was injected into untrained rats, the latter subsequently performed the originally-trained response. The learned behavior involved in these experiments consisted of approaching the food cup in a Skinner box when a distinct stimulus (click or blinking light) was presented. Our results indicated that the response transfer was specific in nature and did not occur in any of several appropriate control groups.

One of the questions raised by these experiments is that of whether the response transfer might be demonstrated in a different behavioral situation. In the present experiment, the RNA transfer effect is examined in a two-choice discrimination apparatus. As in our previous experiments, the injected animals were never rewarded during testing, but were simply given the opportunity in a series of unreinforced test trials to perform the response learned by the donor animals.

Subjects and Apparatus

Ss were 90-110-day-old female Sprague-Dawley rats weighing approximately 250 gm.

The discrimination apparatus is shown in Fig. 1.

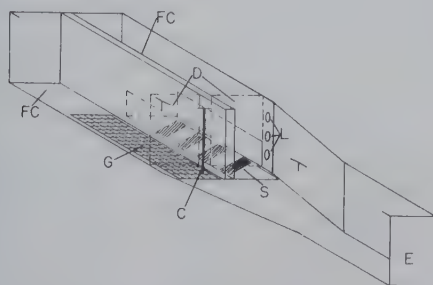


Fig. 1. The discrimination apparatus. Key: FC= food cup; D= guillotine door; G= grid floor; C= beaded chain; S= stripe; L= jewel lights; E= entrance.

A guillotine door was located at the entrance to each alley. Once the rat's entire body (except the tail) was past the entrance, the door to that alley was closed. As can be seen in Fig. 1, the two alternatives differed in a number of respects. One alternative (A) had a fine mesh screen on the floor and a beaded chain hanging in the alley entrance. The other alternative (B) had white contact paper with black tape stripes on the floor and a vertical column of white jewel lights to one side of the alley entrance. Each jewel light was illuminated by a small bulb. Preliminary work showed that with cues combined in this particular way, rats tended to choose A and B with roughly equal frequency. Pellets could be dropped into the food dishes at the ends of the alleys via polyethylene tubes to which funnels were attached. Overhead lighting was diffused, and no attempt was made to reduce extra-maze stimuli.

Procedure

Initially, each of eight rats was adapted to the maze for 15 min. and on the following day was given 11 unreinforced "preference" trials. On preference trials, the rat was placed in the stem and was permitted to run to one side. The door was then dropped and the rat was confined for 15 sec. before being removed from the maze. This procedure also defined a trial during training and during post-injection testing. Preference trials for the first eight rats showed that alternatives A and B were chosen equally (44 choices of each) and that individual biases tended to be small (no rat more extreme than 7 out of 11 choices of one side). On this basis, we decided not to preference-test the rats which were to be injected. Five of the eight rats were then trained in the maze to choose the side they had selected less often on preference trials. For each correct choice the rat was rewarded with four 45-mg Noyes pellets. After each incorrect choice, the rat was simply confined in the alley for 15 sec. Each rat was run on a given day until it had made 25 correct choices and therefore received 100 pellets. No other food was given to these rats during training. Each rat was trained for five consecutive days. By the fifth day, none of the 42 rats trained in the experiment made more than two incorrect choices per daily 25 correct choices.

On the day of completion of training, each of the five rats was sacrificed with ether, and the brain was taken out as quickly as possible. A cut was made on a line joining the superior colliculus to the rostral end of the pons. The tissue posterior to this cut was discarded, as was the tissue of the olfactory bulbs. The

average weight of the tissue retained was 1.3 gm. RNA was then extracted from this tissue by a phenol extraction technique (for details of the procedure, see Babich et al, 1965). The average yield was 1.0 mg/1.0 gm of tissue. The RNA extracted from each brain was dissolved in 2.0 ml of isotonic saline.

Approximately 8 hr. after extraction, the RNA from each of the trained rats was injected intraperitoneally with a 3/4-in 22-gauge needle into an untrained test rat (the xiphoid process was used as a guide for the injection). Prior to injection, each of the test rats had been adapted to the maze for three days, 15 min. per day. The test animals were assigned code letters, and from this point on, all testing was conducted "blind": the testers did not know the group membership of any animal until the completion of testing.

A session of testing for a given rat consisted of permitting that rat to make five runs in the maze. On each trial, the animal was confined for 15 sec. in the side it chose and was then returned to its home cage. The intertrial interval was 4-6 min. Five such testing sessions were given, at 6, 9, 12, 22, and 25 hr. after injection. Each test animal thus received a total of 25 trials. No food was ever given in the maze during testing. At the beginning of testing, all rats were approximately 24 hr. food-deprived. After the third test session, all rats were fed 4-5 gm of Purina Lab Chow.

The five recipient rats from the first week were subsequently trained in the maze (to the side of their respective donor animals) and served as RNA donors in the second week of the experiment. This process was repeated for the remaining four weeks of the experiment as well. In addition, three new rats were trained and used as donors during the third week. Thus, in all, 42 rats were trained in the maze (22 to A, 20 to B) and served as RNA donors, and 42 recipient rats were tested.

Results and Discussion

Table 1 shows the "preferences" of the test animals as indexed by their predominant choices on the 25 test trials, regardless of the strength of preference. As the table shows, rats injected with RNA from A-trained donors tended to choose A on test trials, and "B-injected" rats tended to choose B. By a χ^2 test, the differences are significant at the .02 level (one-tailed test). Absolute preferences were on the whole small (see Table 2).

Table 1. Preferences of injected rats on the 25 test trials. Cell entries indicate the number of rats choosing that alternative.

	Preference of injected rats	
	Side A	Side B
Side to which donor was trained	A 15 B 6	7 14

Table 2. Distribution of scores for recipient rats. Each animal's score is the number of times (out of 25) it selected the alternative (A or B) to which its respective donor rat had been trained.

Score	Frequency
7	1
9	2
10	3
11	2
12	5
13	8
14	7
15	10
16	1
17	1
19	1
21	1

Apparently, then, the specific training given to donor rats was a determinant of the subsequent choices of recipient rats. In addition to confirming our earlier findings in the Skinner box, the present results further indicate that the RNA transfer effect is quite specific in nature. Moreover, the fact that this effect can be demonstrated in widely disparate behavioral situations provides support for the notion that RNA may be critically involved in many memory storage phenomena.

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- Now at Lawrence Radiation Laboratory, Livermore, California.

Contingent and noncontingent responding in squirrel monkeys as a joint function of quality of, distance from, and schedule of food reinforcement¹

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Ss worked on chain FI VI, chain FI DRL, multiple S^{Δ} VI or mult S^{Δ} DRL. In chains, onset of the VI or DRL food link was contingent on right-bar presses in the FI link. In multiples, onset of the food component occurred after a pre-set duration of S^{Δ} , and was not response-contingent. Sucrose or peanut pellets reinforced left-bar presses on the food schedules. Variability among *Ss* was great, but generally, results were: (1) where quality of the reinforcer made a difference, sucrose maintained higher response rates than peanut, whether responding was contingently or noncontingently reinforced; (2) responding in the components distal to food was somewhat more sensitive to quality of the reinforcer than responding in the proximal food components; (3) with food reinforcement rate in VI and DRL equated, there was no significant effect of type of schedule per se on FI responding in chains, but (4) there was a differential effect on S^{Δ} responding in multiples, with less S^{Δ} responding on mult S^{Δ} DRL than mult S^{Δ} VI.

This experiment was motivated by our interest in the determinants of psychogenic polydipsia in rats on dry-food, interval reinforcement schedules (Deadwyler et al, 1965; Segal et al, 1965a, b, c, d, e, f). One explanation of such excessive drinking is that it becomes, adventitiously, the first member of a drinking-bar pressing chain, terminated and reinforced by food. Stein (1964) questioned this interpretation, partly on the basis that his rats drank excessively between bar presses only when the reinforcer was dry food, and not when it was milk. This seemed to him evidence that the drinking was merely thirst-induced, and not adventitiously reinforced. But Stein's data showed that not only did drinking decline under milk; bar pressing also declined, suggesting that milk was a weaker reinforcer. Perhaps, then, drinking disappeared because its controlling reinforcement contingencies were too weak; it was only the distal member of only an adventitious response chain terminating in only a weak reinforcer.

This experiment was done to determine what, in fact, would be the effects of changing the quality of reinforcer on behavior that is distal vs. proximal to food, and contingently vs. adventitiously maintained. The experiment was incorporated into a program of research on operant chaining in squirrel monkeys.

Method

Four adult, male, squirrel monkeys, maintained at 80% of ad lib weight, ran in two identical Lehigh 1417 squirrel monkey chambers, each with two levers, a stimulus lamp directly over each, a food cup, an ad lib water bottle, a ventilator, a speaker feeding white masking noise, a fluorescent houselight, and a one-way vision screen. The

chambers were in sound-resistant shells and were put, together, in a sound-resistant, darkened, experimental room that contained white masking noise. Monkeys 1 and 9 ran at the same time of day, as did monkeys 11 and 12. Monkeys 1 and 11 worked in one chamber on the schedules terminating with DRL food reinforcement, and monkeys 9 and 12 in the other chamber on the schedules terminating with VI reinforcement. Reinforcers were Noyes 45 mg pellets made either of sucrose (S) or a mixture of rat chow and peanut (P). The VI schedule was adjusted to yield an average food reinforcement rate equal to that generated by the performance of the DRL *Ss*; as DRL performance improved, yielding more frequent food reinforcements, the VI reinforcement rate was increased correspondingly. The VI schedule over all sessions reported here was stable at an average inter-reinforcement interval of about 18 sec.

Chain FI 2 min. DRL 10 sec. or Chain FI 2 VI 18 sec.

During the FI link, only the lamp above the right bar was lit, green, and right-bar presses produced the conditions for the food (DRL or VI) link on an FI 2. During the food link, only the lamp above the left bar was lit, red, and left-bar presses produced food on DRL 10 sec. or VI 18 sec. Only one reinforcement was permitted in each cycle; its arrival recycled the chain to the first, FI link. Fifty cycles of the chain were run daily, in sessions that initially had sucrose as the reinforcer. Thereafter, blocks of sucrose and peanut sessions were run until behavior appeared stable under each.

Mult S^{Δ} 2 min. DRL 10 sec. or Mult S^{Δ} 2 VI 18 sec.

The only change was that right-bar presses were ineffective, and 2-min: S^{Δ} periods marked by a green light over the right bar automatically intervened between each one-reinforcement period on DRL or VI. Sessions began with an S^{Δ} period and ended with a food reinforcement. Midway through the first peanut block, sessions were lengthened to 75 cycles.

The shift from chains to corresponding multiples permitted evaluation of the effects of the main variable, sucrose vs. peanut, on contingently-reinforced (FI) vs. adventitiously-reinforced (S^{Δ}) responding distal to food. Use of two-component schedules permitted evaluation of the effects of the main variable on responding that was distal (FI or S^{Δ}) vs. proximal (DRL vs. VI) to food.³

Results and Discussion

Figure 1 shows total daily responses of *Ss*, from the 14th day of the experiment on. By this point behavior was generally appropriate to the contingencies and the VI schedule was stable.

Proximal contingent responding.

Monkey 1, working on the DRL, showed stable responding that was only slightly higher under sucrose than peanut. Monkey 11, also working on DRL, showed stable responding for sucrose, but would not eat peanut pellets even when supplementary rations were withheld for a few days, and ceased responding earlier and earlier in each successive peanut block. It was not run at all in the final peanut block. Monkey 12, working on the VI, showed stable responding that did not alter as a function of sucrose vs. peanut. Monkey 9, whose VI behavior was much more variable, showed, at most, only a very slight preference for sucrose.

Distal contingent responding.

Monkey 1's FI response rate was slightly higher under sucrose than peanut. Behavioral contrast is evident in the fact that rate fell or rose when a shift in reinforcer first occurred, but stabilized at roughly the same level for both reinforcers. Monkey 11's responding was ex-

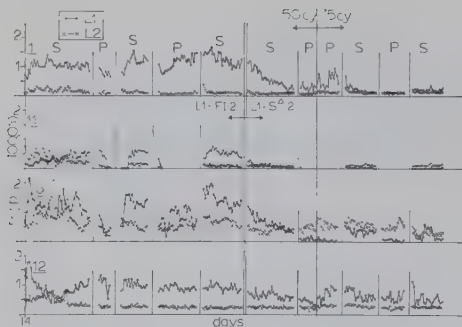


Fig. 1. Total daily responses of each S from day 14 on. Solid lines: right (reinforced) bar presses during the first (FI or S^A) "link." Crosses: left (reinforced) bar presses during the second (VI or DRL) "link." Increases in total daily responses following the shift from 50 to 75 cycles per day reflect the greater length of sessions, and not increases in response rate.

tremely sensitive to the quality of reinforcer, but it is not possible to compare the effects on proximal and distal responding, in view of the relatively complete absence of responding for peanut. Monkey 9's FI responding was very sensitive to quality of reinforcer, being distinctly higher for sucrose. Monkey 12's FI responding was about as stable as its VI, and about equally insensitive to the quality of the food.

Summary.

In those Ss that responded differentially to sucrose vs. peanut (1, 11, 9), the effect was more marked on distal than proximal responding in monkeys 1 and 9.

Distal noncontingent responding.

All Ss showed a decline in right-bar pressing when the first component became S^A , making right-bar presses non-functional. The decline was more rapid, and rates thereafter remained generally lower, in the two DRL monkeys. Monkey 1 showed a very slightly higher S^A response rate in sucrose sessions, evident mainly in the comparison between the last peanut and sucrose blocks. Monkey 11 showed no differential response to sucrose vs. peanut; its S^A responding under sucrose rapidly reached zero, and could not have been lower, and surely would not have been higher, under peanut. Monkey 9 showed a preference for sucrose. Only at the very end of the experiment did it seem that sucrose-maintained S^A responding was extinguishing, although S^A responding under peanut had seemed to be extinguished much earlier. Monkey 12's S^A responding did not decline so far below its FI level as in the other Ss, and the behavior was stable and insensitive to quality of reinforcer, as its FI and VI behavior was.

The fact that the adventitiously-maintained S^A behavior of monkeys 1 and 9 was affected by quality of reinforcer indicates that this variable may, indeed, considerably alter an S's propensity to respond in the distal member of an adventitiously-maintained response chain. Our interpretation of Stein's data on polydipsia as a function of milk vs. pellet reinforcers is at least tenable, and his data do not, of themselves, support the position that polydipsia is entirely thirst-controlled.

First-link responding as a function of the second-link schedule: I. FI.

Except for the aberrant performance of monkey 11, there is no indication in the data of Fig. 1 that making food available on a DRL vs. a VI schedule affected the conditioned reinforcingness of the food-correlated stimuli, as reflected in the FI responding, which was reinforced by onset of those stimuli. Monkeys 1, 9 and 12 all showed comparable FI rates that varied roughly about 1,000-1,500 per 50-cycle session. Apparently, the equated food-reinforcement rates yielded about equal conditioned reinforcingness for the correlated stimuli. II. S^A .

On the other hand, Fig. 1 shows that, overall, there was more S^A responding in VI than in DRL monkeys. Again, the (adventitious) reinforcer for such responding must have been onset of the stimuli correlated with the availability of food, and the FI data indicate that the reinforcement value of these stimuli was about equal in the two groups. The explanation of the differential amount of S^A responding must, then, depend on some other variable. The most likely explanation is induction to S^A periods of the response pattern maintained in DRL vs. VI periods. VI maintained a higher response rate than DRL, and this difference apparently generalized to S^A periods.

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Notes

1. Supported by NSF GB 1605 and NIMH 8505.
2. On leave at the Department of Pharmacology, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2. Send reprint requests to Mr. David L. Oden, Department of Psychology, San Diego State College.
3. Use of the two different food schedules, with equated reinforcement rates, yielded data on a question extraneous to the main purpose of the experiment, but important to the analysis of chaining and conditioned reinforcement, viz., whether the type of primary reinforcement contingency contributes to the conditioned reinforcingness of its correlated stimuli, independently of primary reinforcement rate.

Positive reinforcement: A test of the Premack theory¹

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Two human Ss were tested on a key pressing task in which two keys produced the same reinforcer, counter points, but on different reinforcement schedules. The results of a contingency arranged between the two keys supported Premack's reinforcement theory; not only do high rate responses reinforce low rate responses, but they do so even when both responses depend on the same reinforcer.

The generalization that, for any pair of responses, the independently more probable response will reinforce the less probable one represents the basic assumption of a recent reinforcement theory (Premack, 1959, 1961, 1965). A test of the theory requires first, that the rates of the two responses be determined in a noncontingent period in which both responses are simultaneously and freely available to the Ss, and, second, that a contingency be arranged in which the opportunity to engage in the high rate response is dependent upon the occurrence of the low rate response. Previous tests of the theory on rats have shown that the generalization accounts for the reinforcement of bar pressing by drinking, running by drinking, and drinking by running (Premack, 1961, 1962; Schaeffer, 1965). In monkeys, the theory accounts for differential contingent rates of lever manipulation (Premack, 1963). In humans, the generalization holds for the reinforcement of eating by pinball playing, and pinball playing by eating (Premack, 1959).

In each of the preceding tests of the theory, the behavioral topography and consequences of the two responses differed markedly, viz., bar pressing and drinking, running and drinking, ratchets and plungers, eating and pinball playing. Will the theory also hold for two identical responses, each of which produces the same reinforcing event, but under different schedule requirements? The present study tested this question.

Method

The Ss were a male undergraduate and a female undergraduate enrolled in an introductory psychology class. Both Ss were 19 years old. They were selected on the basis of volunteering to report at the same time daily for unpaid 10 min. test sessions over three consecutive weeks.

The apparatus consisted of a Bud CU-2107 MiniBox in which a Sodeco counter was mounted between two Switchcraft type 60324 telephone keys. One key was programmed on CRF; the other was programmed on FR5. Under the appropriate conditions each depression of the CRF key produced one point on the S's counter, and five depressions of the FR5 key produced one point on the S's counter. A large soundproof test room isolated the Ss from the programming equipment in the adjacent control room where each CRF and FR key depression

and total points that appeared on S's counter were recorded.

On the first test day the Ss were conducted into the test room, shown the test box, and given the following instructions: "This is a test of motor coordination. Your job is to try to get as many points as possible in the next 10 min. Begin when you are ready." The E then left the room, returned in 10 min., dismissed S, and requested that S return at the same time the next day. No further instructions were given over the remaining 16 test sessions.

Each S was carried through the following five conditions: six days during which both keys were simultaneously and freely available and produced points on their respective schedules (i.e., paired operant sessions); four days during which the CRF key was placed on extinction; two days during which the FR5 key was placed on extinction; four days of the contingent case; and finally, one day on which the Ss were returned to the original paired operant condition in which both keys were simultaneously available and produced points on their respective schedules. In the extinction procedures the key placed on extinction was freely available to S but did not produce points on S's counter; the key not on extinction was also freely available to S and did produce points on S's counter. In the contingent case, the higher rate key in the paired operant sessions (the CRF key) was made contingent upon the low rate key (the FR5 key); the CRF key could produce points on S's counter only during the 10 sec. interval that immediately followed completion of each FR5 requirement.

Results

Rate of key pressing for both Ss in the initial paired operant, in CRF extinction, in FR extinction, in the contingent case, and in the final paired operant are shown in Fig. 1. Rate of responding on the CRF key clearly exceeds rate of responding on the FR key for both Ss in the paired operant sessions. Extinction of the CRF key had the effect of an immediate increase in rate of responding on the FR key and a simultaneous reduction of CRF key rate for both Ss. Extinction of the FR key reduced the FR key response rate for both Ss, more dramatically for the male who had a higher paired operant FR key rate than for the female. Rate of responding on the CRF key was largely unaffected by the FR extinction procedure. In the final paired operant, rates of responding on both keys for both Ss show good recoverability of the baseline response rates that were obtained in the original paired operant.

The reinforcing effect of the higher rate CRF key is evident in the increased rate of FR key responding in

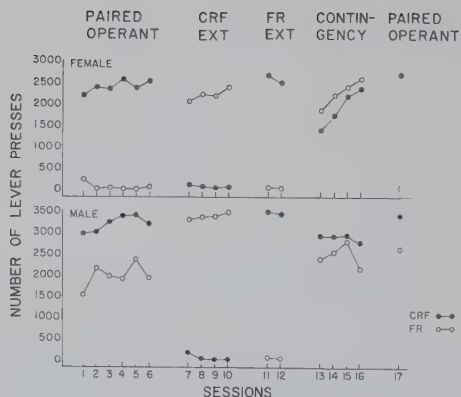


Fig. 1. Total number of CRF and FR lever presses per session for each of the five experimental conditions for the female S (upper panel) and the male S (lower panel).

the contingent case. The magnitude of the reinforcement effect was assessed by a procedure originally suggested by Schaeffer (1962); namely, subtracting mean rate of the instrumental response in the paired operant condition from mean rate of the instrumental response in the contingent case. Using this procedure, the mean reinforced increments in FR key pressing associated with the contingency were 2292.2 and 481.3 for the female S and the male S, respectively.

Differing rates of responding are evident for the two Ss in the contingent case; the male S, who had a high rate of FR key responding in the paired operant, reached asymptote on the third day of the contingency, while the female S, who had a low rate of FR key responding in the paired operant, was still increasing her rate after four days of the contingency.

Discussion

The prediction has often been made in private discussions that Premack's reinforcement theory would not hold for cases in which a given reinforcer was contingent upon two similar responses with different schedule requirements. The rationale for this prediction is as follows: first, for a specific reinforcer, and a specific instrumental response, FR schedules, when tested separately from CRF schedules, produce higher response rates than do CRF schedules (Skinner, 1938); second, any attempt to make the higher rate response (the FR response) contingent upon the lower rate response (the CRF response) would fail to reinforce the lower rate CRF response, since the lower rate response would itself be reinforced when it occurred, the rein-

forcement being sufficient to preclude any occurrence of the contingent FR response. It must be pointed out that this prediction, and the rationale underlying it, is based upon a misunderstanding of Premack's basic assumption: namely, that response rates must be determined in the case where both responses are simultaneously available to the S so that S may choose freely between them. Premack's theory makes no assumptions about the reinforcement effect where each response is tested separately, and the S has no choice of responses. Furthermore, as was evident in the present study, when two responses with different schedule requirements which produce the same reinforcer are concurrently available, the S chooses the response with the lower schedule requirement more frequently than the response with the higher requirement. Thus, the ordinal relation between CRF and FR5 response rates when tested concurrently is obviously the inverse of the traditional case where CRF and FR5 are tested separately. Nonetheless, the present study provided a test under conditions for which it has been assumed the differential rate reinforcement generalization would not hold. The present results provide further confirmation for the general applicability of Premack's reinforcement theory. The differential rates of approach to asymptotic contingent responding that were found in the present study also support the contention that rate of responding in the contingent case is partly influenced by the independent rate of the instrumental response, and is not entirely attributable to the independent rate of the reinforcing response (Premack, 1965; Schaeffer, 1965).

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Note

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Response force under fixed-interval reinforcement¹

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The force of lever-pressing was measured under a 1-min. fixed-interval schedule of food reinforcement. The Ss, 6 rats, were tested under 4 conditions of response force requirement imposed in the following order: 22, 52, 22, and 7.4 gm. In one analysis, it was found that the average force of lever-pressing gradually increased in magnitude during the 1-min. intervals. Under the higher force requirements, it was found that criterion responses were less numerous and occurred closer to the end of the fixed-interval. Sub-criterion responses, however, remained numerous at higher force requirements. After the imposition of the highest (52 gm) requirement, it was found that a higher average force characterized the performance even after 5 weeks' exposure to lower values.

Problem

A growing area of interest in the field of operant conditioning is the study of the intensive properties of responding. We have been concerned with the measurement of the force of lever pressing in rats. Recently response force has been studied under continuous reinforcement and extinction (Notterman, 1959), discrimination (Notterman & Block, 1960; Notterman & Mintz, 1962), and fixed-ratio (Mintz, 1962) schedules. Goldberg (1959) has recorded fixed-interval performance, but only for a limited amount of time (one session). The present paper provides more complete information on the characteristics of response force during fixed-interval reinforcement.

The experiment was designed to study changes in stable-state responding as force requirement is varied. In the design, the performance was to be re-established under the original requirement after each variation. However, an apparent irreversibility occurred after exposure to a high (52 gm) force requirement. We therefore modified our design and tested the strength of this relatively permanent change in behavior by imposing a very low (7.4 gm) requirement.

An important feature of the experiment is the measurement of "sub-criterion responses." These are lever presses which are not of sufficient force to meet the force requirement for reinforcement and are distinguished from "criterion responses."

Method

Six adult, male, Wistar-derived rats from the colony of the Walter Reed Army Institute of Research were used as Ss. The rats were maintained at 80% of their free-feeding weights by feeding them an appropriate quantity of solid food at the end of each session.

The rats were tested in a Foringer rat experimental chamber. Reinforcement was the delivery of a 45-mg Noyes rat food pellet by a Gerbrands pellet dispenser

and was accompanied by a 1-sec. buzzer. One end of a lever projected 15 mm from the wall into the chamber, was 15 mm in width, and was 13 mm in thickness except at the end where it was rounded. The other end of the lever pressed upward against a Grass Model FT-03 Force Displacement Transducer. The transducer was designed for isometric measurements and was displaced only 0.1 mm by a 100 gm force.

Signals from the transducer were recorded continuously by a Grass Model 5 polygraph and were analyzed by a system of Philbrick K2-W operational amplifiers into different amplitude categories, providing digital outputs for counters and programming equipment.

In our analysis, lever presses were recorded only if they met the following 3 criteria: (1) The peak value of the force of a downward lever press had to be greater than 7.4 gm. (2) The applied downward force must pass from 4 gm to the specified value in less than 0.15 sec. (3) It was arranged that a snapping action of the lever which began with an upward motion would not be recorded as a response. Counters were used to record the number of lever presses which exceeded each of 3 values: 7.4, 22, or 52 gm.

After magazine training, every lever-press meeting the 22-gm force requirement was reinforced. One-hour daily sessions were then conducted with reinforcement under an FI-1 schedule. The force requirement was, successively, 22, 52, 22 and 7.4 gm, with each requirement in effect for 21, 12, 24, and 12 sessions, respectively.

Results and Discussion

For each S, the average force of lever-pressing during the 1-min. interval increased in magnitude.³ In some cases, this gradient is apparent from an examination of the polygraph recordings for single intervals. The slope and form of the gradient varied for each S and was uncorrelated with force requirement.

Changes in force of response as a function of the requirement are shown in Fig. 1. The median number of responses for the 6 Ss in each of 3 ranges of peak force are shown. All the curves show a pronounced "hysteresis" effect. It can be seen, for example, that during the second exposure to the 22 gm requirement more responses of high force (52 gm or greater) were emitted than during the first exposure to this requirement. The number of responses exceeding 52 gm increased as response requirement increased, whereas the frequency of responses of the lowest forces (7.4 to 22 gm) tended to decrease.

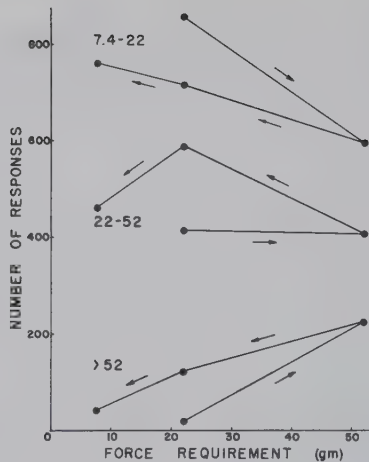


Fig. 1. Median number of responses for the 6 Ss in each of 3 ranges (7.4 - 22, 22 - 52, greater than 52 gm) of peak force. Values are medians for the last 6 sessions under each force requirement. The arrows show the order in which the requirements were imposed.

The temporal distribution of responses within the fixed-interval was evaluated by the quarter-life measure (Herrnstein & Morse, 1955), which is a measure of the time necessary for the emission of one-fourth of all the responses emitted in an interval. It was found that the quarter-life computed for criterion responses tended to increase with higher force requirements, but the quarter-life computed for the combined criterion and sub-criterion responses remained relatively constant.

The number of criterion (Fig. 2, curve A), but not the number of all, i.e., combined criterion and sub-criterion, responses (Fig. 2, curve B) was a function of the force requirement. (Note, again, the "hysteresis" effect in both curves.) This result indicates that although increases in the force requirement of a response may reduce criterion response output (cf. Chung, 1965), the total number of responses, criterion and sub-criterion responses combined, may remain invariant. The generality of this finding for other schedules or other behavioral situations requires further investigation.

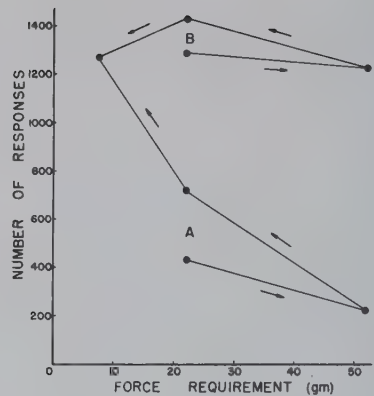


Fig. 2. Median number of criterion (curve A) and combined criterion and sub-criterion (curve B) responses for the 6 Ss. The minimum force recorded was 7.4 gm. Values are medians for the last 6 sessions under each requirement. The arrows show the order in which the requirements were imposed. Note that the point at the 7.4 - gm requirement is common to both curves.

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Notes

1. This investigation was supported by P. H. S. Research Grant MH-01604 from the National Institute of Mental Health.
2. During the performance of the experiment, P. H. S. Fellow, IFIMH-20, 985-01.
3. Data on this aspect of the results, as well as greater details on other parts of the experiment is contained in the Laboratory of Psychopharmacology Technical Report No. 64-41, available on request.

Goal gradient during acquisition, partial reinforcement, and extinction of a five part response chain¹

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Seventeen rats were trained to turn 5 wheels in sequence in order to obtain water reinforcement. During acquisition, rate of wheel turning increased as Ss approached the goal. During the partial reinforcement phase, the shape of the performance gradient remained about the same. However, a general increase was noted at every wheel except the one closest to the goal. During the extinction phase, the Ss stopped responding most quickly to the wheels closest to the goal.

A previous study (Bruning, Becker, & Tucker, 1965) demonstrated the effects of the presence of cues on the acquisition and extinction of a five part response chain. The present investigation is concerned not only with the effects of different cues, but also with reinforcement schedules as they affect response strength at various points along the response chain.

Method

Subjects.

The Ss were seventeen female albino rats (Sprague-Dawley strain), 110-130 days of age. All Ss were maintained on a 23 1/2 hr. water deprivation schedule. Apparatus and Pretraining.

The apparatus and the pretraining techniques have been described previously (Bruning, Becker, & Tucker, 1965).

Acquisition.

After the pretraining sessions, Ss were placed in the apparatus and allowed to freely respond for one 5-min. trial each day. As in the previous experiment, the light above wheel No. 5 (farthest from the dipper) was initially turned on. After the Ss had turned all five wheels in sequence, the dipper mechanism activated and delivered .1 cc of water. After the dipper retracted, S had to again perform the sequence to obtain another reinforcement. Acquisition trials for all animals were under 100% reinforcement and were continued until performance stabilized (10 5-min. trials).

Partial Reinforcement.

Immediately following acquisition, the Ss were randomly divided into two groups ($N=9$; $N=8$). In the first group, the lights above the wheels were left operable so that the cue remained. In the second group, the cue lights were switched off. Both groups were then placed on a partial reinforcement schedule in which the terminal reinforcement was given a random 50% of the time. Thus, on the average, the Ss had to complete the sequence twice to obtain a single drink. Six 5-min. trials were given each S.

Extinction.

Following the six trials under partial reinforcement, both groups were given six extinction trials. The cue conditions during extinction were the same as were present during the partially reinforced trials.

Results and Discussion

Data from six trials under each treatment condition (acquisition, trials 5-10; partial reinforcement, trials 11-16; extinction, trials 17-22) were grouped together for purposes of statistical analysis and graphical representation. The analysis of variance was computed to determine the effects of cues, wheel position, and reinforcement condition on performance. This analysis indicated, first, that the main effects of cues was not significant and also that none of the interactions involving cues was significant (cues, $F=3.83$, $df=1/15$; cues by treatments, $F<1$, $df=2/30$; cues by wheels, $F<1$, $df=4/60$; cues by treatments by wheels, $F=1.29$, $df=8/120$). Since the presence or absence of cues had no effect, the data presented in Fig. 1 represents the combined performance levels of the two cue groups. A possible explanation for the lack of difference due to cues may be that since the Ss were highly trained at the termination of the acquisition phase, the external light cues became relatively unimportant for successful performance of the chain, and the animals relied almost entirely on various proprioceptive cues.

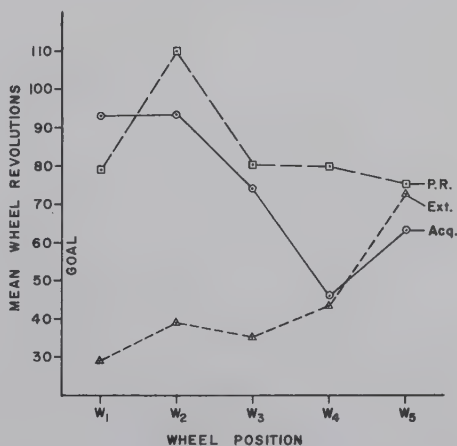


Fig. 1. Mean performance level as a function of wheel position and reinforcement condition.

Inspection of Fig. 1 reveals that response strength varied considerably as a function of reinforcement condition and wheel position. This was supported by the analysis which showed the effects of reinforcement conditions ($F=34.7$, $df=2/30$, $p<.001$), wheel positions ($F=8.28$, $df=4/60$, $p<.001$), and the reinforcement by wheel position interaction ($F=6.34$, $df=8/120$, $p<.001$) all to be significant.

As was noted in the previous study, the general trend during acquisition was for response strength to increase as the S neared the goal. The change to partial reinforcement resulted in an increased rate of wheel turning at every wheel except No. 1. Also, as can be noted from Fig. 1, the tendency was for some flattening of the goal gradient to occur. During extinction, the results were consistent with those of the previous

study in that the responses most closely associated with the goal were the first to extinguish.

In addition to the wheel turns made by the Ss, the number of sequences completed was also recorded. These results were generally consistent with those relating to wheel turning. During the acquisition phase, the mean number of sequences completed during the last six trials was 86; during partial reinforcement, the number rose to 116, and during extinction, it dropped to 39 ($F=4.43$, $df=2/34$, $p<.025$).

Reference

Bruning, J. L., Becker, P. W., & Tucker, R. C. The effect of goal proximity on acquisition and extinction of a five part response chain. *Psychon. Sci.*, 1965, 3, 211-212.

Note

1. Portions of this paper were read at the 1965 Midwestern Psychological Association meeting in Chicago.

Reward magnitude shifts: A savings effect¹

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Two groups of rats were first trained to traverse a runway, one with large and the other with small food rewards. Both groups were then given additional training with small rewards until their performance equalized. In final training, both groups were shifted to the larger rewards. The group with a prior history of large rewards, evidenced savings in the final stage of training, in terms of a faster rate of performance change to the level appropriate to the larger reward.

Under certain conditions the magnitude of reward variable can be shown to have relatively persistent effects upon the runway performance of the rat. Thus, Ss trained with large, as compared to small, rewards when subjected to experimental extinction will continue to evidence their different reward histories over the course of extinction (e.g., Wagner, 1961; Hulse, 1958). Under other conditions, however, reward magnitude appears to have a less persistent influence. Thus, Ss trained with large rewards and then shifted to smaller rewards will, after a relatively small number of postshift trials, come to respond at speeds indistinguishable from those of Ss trained only with small rewards (e.g., Crespi, 1944; Zeaman, 1949). A question which this poses is whether shifting to a new, but nonzero, value of reward is an especially effective method of eliminating any influences of prior reward magnitudes, or whether relatively persistent historical influences exist but are simply not observed in performance under these conditions? The results of the present investigation of shifts in reward magnitude support the latter interpretation.

Method

The Ss were 40 male albino rats, 90 to 110 days of age at the beginning of the experiment. They were randomly assigned to two groups of 20 Ss each.

The apparatus was a straight, enclosed alley 3 in wide and 4 in high throughout, divided by guillotine doors into a 12-in start box, a 45-in runway, and a 15-in goal box. A 1-in deep food cup was attached to the end wall of the goal box with its rim 1.5 in from the floor. Total-Response time was measured from the opening of the start box door until the interruption of a photocell beam just prior to the rim of the food cup, and was fractionated by means of intermediate photocells located 12 in and 48 in from the start box, into three successive segments, start-time, running-time, and goal box-time.

Ten days prior to experimental training, Ss were placed on a 24-hour food deprivation schedule and brought to between 75% and 80% of their ad lib, 100-day weight. The Ss were maintained within this range throughout the experiment by limited feedings 30 min.

after daily training. During the course of these 10 days, Ss were habituated to the experimental situation by systematic handling, exposure to wet mash pellets scattered on a raised platform, exposure to the runway in groups of three, and finally, two direct placements in the goal box of the alley with a wet mash pellet (.5 gm dry weight) in the food cup.

Experimental training for all Ss consisted of one alley trial per day for 88 days. A trial was begun by placing S in the start box. When oriented to the start door, the door was raised, allowing S to traverse the alley. On each trial a wet mash pellet, pressed from a mixture of 2 parts (by weight) Purina Lab Chow powder and 1 part water, was available in the food cup. The S was removed from the goal box immediately after eating and returned to its home cage.

The treatment of the two groups differed only in the amount of reward received during the first of three stages of training. Group LSL received 1.0 gm (dry weight) rewards during the first 43 trials (Stage I). Group SSL received .1 gm rewards during the same period. During the next 16 days (Stage II) both groups received .1 gm reward, and during the last 29 days (Stage III), 1.0 gm reward. Thus in the three stages, Group LSL received first large, then small, and finally returned to large reward, whereas Group SSL received small reward during the first two stages and first encountered the larger reward during Stage III.

Results and Discussion

Figure 1 presents mean Total-Response speeds for the two groups during the three stages of training. During Stage I, when Group LSL received 1.0 gm reward as

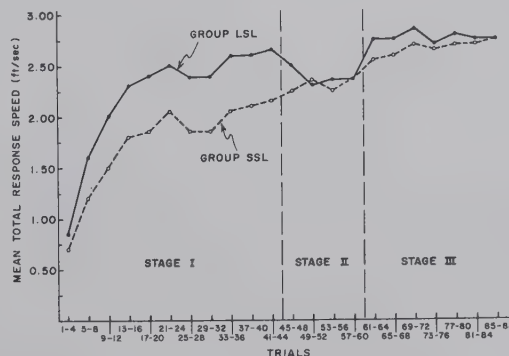


Fig. 1. Mean Total-Response speeds for groups of 20-Ss receiving a sequence of either large, small, large (LSL) or small, small, large (SSL) rewards in three successive stages of runway training. Changed reward size when appropriate according to these sequences was introduced at the termination of trials 44 and 60, after the completion of the response measure reported.

compared to .1 gm for Group SSL, the former group consistently ran faster than the latter. The difference in mean Total-Response speeds on the last four trials in Stage I was highly reliable, $t(38) = 3.40$, $p < .001$.

The response speed of the two groups equalized after 4 trials of Stage II, when both received the same small reward. The speeds remained similar until after the beginning of Stage III, when 1.0 gm rewards were resumed for Group LSL and introduced for the first time for Group SSL. Although both groups received the same magnitude of reward during this stage, the initiation of Stage III was quickly followed by a re-separation of the performance of two groups.

On the first block of 4 Stage III trials following the reintroduction of large reward (i.e. trials 61-64) Group LSL attained a mean speed of running which was maintained with but small fluctuations over the remainder of Stage III. In comparison, Group SSL showed a more gradual increase in running speed, before reaching the same level as Group LSL. A comparison of the increase in running speed on trials 61-64 over the preceding block of 4 trials prior to the receipt of the larger reward yielded a significantly greater change for Group LSL than for Group SSL, $t(38) = 2.43$, $p < .02$.

While the Total-Response measure presents a clear picture of *savings*, Group LSL returning faster to a level of performance appropriate to the larger rewards than Group SSL, this effect was not universally observed in the several component measures. Starting speeds revealed no differences between the groups in Stage III, and goal box speeds showed the largest separation of the two groups. That is, the effect became more pronounced as Ss behavior was measured nearer to the goal area.

According to Hull-Spence theory (e.g., Spence, 1956) different magnitudes of reward may be presumed to lead to the conditioning of anticipatory reward responses ($r_g - s_g$) of different vigors. When Ss are shifted from large to small rewards it may be assumed that a new and less vigorous r_g becomes prepotent, similar to that which exists for consistently small rewarded Ss. The savings effect presently observed suggests that this change is not accompanied by an "unlearning" of the more vigorous r_g . The more vigorous r_g apparently remains available to be more quickly reinstated as prepotent when reward magnitude is again increased.

Another interpretation is possible within the general notion that relearning is faster than original learning. According to Logan's micromolar extension (e.g., 1960) of Hull-Spence theory, it might be assumed that Group

LSL had learned during Stage I to run at a fast speed, and that the savings observed in this group in Stage III was a result of fast responses being more available to again become prepotent.

It could also have been possible that different cues were present on large reward than on small reward trials, so that the superior performance of Group LSL in Stage III could have reflected prior acquisition training to a set of cues to which Group SSL was naive. Common precautions were taken to avoid this possibility, e.g., Ss could not see the reward until after the response measures were taken, and a 24-hour intertrial-interval was employed to minimize aftereffect cues from the preceding reward. One empirical check on the absence of differential cues other than reward aftereffects, is the performance of the two groups on trial 60, on which reward magnitude was shifted from small to large for all Ss, but on which the change should not have been appreciated by S until after the response measures were completed. On this trial there were no differences between the two groups on any of the response measures and no significant changes from trial 59 in either group.

As pointed out, the present data may be consistently integrated within Hull-Spence theory. This theory assumes that reward magnitude does not influence the habit strength (H) of the running response, but rather effects the performance of the running response through the incentive motivational properties of $r_g - s_g$. The data do not, however, agree with the casual generalization that reward magnitude influences "performance" but not "learning." Indeed the present results suggest that the history of reward magnitude may have relatively persistent effects, indicative of "learning" although it may not influence "performance" in all situations.

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Note

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Effect of electroconvulsive shock on inhibition of an active avoidance response

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After a series of 0, 8, or 16 electroconvulsive shock (ECS) treatments, rats were trained to make an active avoidance response from the left side of a two-compartment box to the right side, in order to avoid foot shock. Following criterion performance, punishment-extinction began, whereby S received foot shock in the right compartment. Neither 8 nor 16 ECS treatments had an effect on acquisition of the active avoidance response and 8 convulsive treatments did not impair inhibition of the response during punishment-extinction. However, Ss given 16 ECS's were significantly inferior to controls in inhibiting the previously learned response. Results were interpreted in terms of impairment of the neural system underlying freezing behavior, produced by the 16 ECS treatments.

Vanderwolf (1963) has reported that a series of electro-convulsive shock (ECS) treatments, administered prior to avoidance training in a bidirectional shuttle box, facilitates acquisition. The improved performance of ECS-treated Ss is hypothesized to result from impairment of the neural system which underlies freezing behavior. Thus, while normal animals crouch and freeze to the CS (as a result of inhibitory processes set by forcing them to return to the side where previously shocked), animals given ECS treatment prior to training do not display the competing response of freezing. If a separate neural system does mediate freezing behavior and ECS impairs this system, animals treated with ECS should be inferior in learning situations where freezing or inhibition is required for correct responding, e.g., passive avoidance.

A series of ECS treatments has been found to proactively impair acquisition of a passive avoidance response in a hunger-fear conflict situation (Poschel, 1957). The purpose of the present experiment was to determine whether ECS also impairs inhibition of a well-learned active avoidance response when it is subsequently punished. Following 0, 8, or 16 ECS treatments, three groups of rats were first trained to go from one side of a two-compartment box to the other, in order to avoid foot shock. After acquisition of the first response, Ss received foot shock for making the response. Thus, a punishment-extinction procedure (Kamin, 1959) was employed in which inhibition of the first-learned active avoidance response was required.

Method

The Ss were 39 female albino rats, 150-170 days old, from the Ohio University colony.

The apparatus was a 36 in by 14 in by 4-1/2 in wooden shuttle box, painted a flat black. A 3 in wide

guillotine door, which could be manually raised, divided the box into two equal compartments. The floor was constructed of 1/8 in stainless steel rods, spaced 5/8 in apart, and both sides could be charged with 1.0 ma current (UCS) from a C. J. Applegate stimulator (Model 250). The front of the apparatus was constructed of clear Plexiglas, covered with black paper, except for a 1-1/4 in wide observation window at the bottom, which ran the length of the box. An 84 db buzzer was mounted behind the back wall of the left compartment. Background noise in the apparatus was 64 db. The ECS was produced by a 50 ma a.c. current of 0.2 sec. duration, and was delivered to S's pinnae through padded alligator-clip electrodes, soaked in a weak sodium bicarbonate solution.

Two groups of 13 Ss each received 8 (Group 8E) or 16 (Group 16E) daily grand mal convulsive treatments in their home cages. A control group (N=13) received PECS (pseudo-ECS: electrodes attached to pinnae but no current delivered) for 8 days. Training began 2 to 5 days after completion of ECS or PECS treatment.

After a 3 min. habituation period in the left side of the apparatus, 5 unreinforced presentations of the CS (buzzer on and guillotine door up) were given. Each presentation lasted 5 sec. with 60 sec. between CS onsets, and number of crossings to CS was taken. Training began with the sixth CS onset, which was followed 5 sec. later by UCS (Session 1). When S entered the right compartment, CS and UCS terminated simultaneously. An avoidance response was defined as entry into the right compartment within 5 sec. after CS onset, whereby S could terminate CS and avoid UCS. Following entrance into the right compartment, S remained there for 45 sec., then was placed into the center of the left compartment, facing the door, 15 sec. prior to the beginning of the next trial. Each S was trained to a criterion of 10 consecutive avoidance responses.

One minute after S met the active avoidance criterion, punishment-extinction began (Session 2). When S responded within 5 sec. after CS onset, it received an immediate 1 sec. foot shock in the right compartment, shock and CS terminating simultaneously. When S failed to respond within 5 sec. after CS onset, CS terminated, and S was credited with a failure to respond and allowed to remain in the left compartment until the next CS onset 60 sec. later. In Session 2, S was trained to a criterion of 10 consecutive trials of no response to CS (punishment-extinction criterion).

Results and Discussion

An analysis of variance of the number of crossings during the 5 nonreinforced presentations of the CS indicated a significant difference between groups ($F=3.84$, $df=2/36$, $p<.05$). Individual comparisons with Duncan's multiple range test (Edwards, 1960) showed that the controls made significantly more crossings than Group 8E ($p<.05$). No other differences were observed. The finding that ECS depressed nonreinforced responding contradicts Vanderwolf's (1963) report of no differences between controls and ECS groups. However, Vanderwolf gave 21 ECS treatments, while in the present experiment eight ECS treatments depressed response to the nonreinforced CS, whereas 16 treatments had no effect (when compared with controls).

For analysis of the number of trials to criterion in active avoidance (Session 1) and punishment-extinction (Session 2), scores were converted to square root transformations ($\sqrt{X}$) to stabilize the variance. A trend analysis over both sessions indicated only a significant ECS effect ($F=5.84$, $df=2/36$, $p<.01$). Further individual comparisons (Duncan's multiple range test) yielded no difference between the groups in Session 1, indicating ECS did not impair acquisition of the active avoidance response. Vanderwolf (1963) found similar results for the same type of learning task. Comparison of group means in Session 2 showed that Group 16E took significantly more trials to punishment-extinction criterion than controls ($p<.01$), while no other differences were observed.

Thus, a series of 16 ECS treatments, while not impairing acquisition of the active avoidance response, hindered inhibition of the same response when it was subsequently punished. A series of 8 ECS treatments, on the other hand, had no effect on learning in Session 1 or Session 2, suggesting that convulsive treatment has a cumulative effect whereby progressive destruction of neural areas may occur.

The present results lend support to Vanderwolf's (1963) hypothesis that ECS impairs the neural system underlying inhibitory or freezing behavior, and also extend the results of Poschel (1957) who found ECS animals were slow in learning a passive avoidance response requiring inhibition of a prior food-rewarded learned task. Thus, it appears that ECS proactively impairs inhibition of an active avoidance response in a manner similar to its impairment of inhibition of an appetitive learned response.

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Demonstration of the Kamin effect after one-trial avoidance learning¹

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In two experiments, groups of rats were trained to make a one-trial avoidance response, and were given a test of retention at various intervals afterward. The result in both experiments was a U-shaped retention function (Kamin effect). Because of the nature of one-trial avoidance learning, the Kamin effect does not seem attributable to warm-up factors or to a temporary state of overarousal.

Kamin (1957) found a U-shaped retention function with its lower extremum 1 hr. after initial shuttle-box training. Kamin's methods and results have since been replicated by Brush, Myer, & Palmer (1963), Denny (1958), Denny & Ditchman (1962), Denny & Thomas (1960), and Kamin (1963).

Because the Kamin effect has been demonstrated only after shuttle-box training, the initial decline of performance on relearning trials can be attributed to an increase in fear, resulting in freezing behavior, or to a decrease in fear, resulting in less motivation. In addition, it is difficult to separate the effects of fear and warm-up during shuttle-box relearning trials. The following two experiments demonstrate a Kamin effect after one-trial avoidance learning, and thus provide a solution to these problems.

EXPERIMENT 1

Procedure

Eighteen, experimentally naive, male, black-hooded rats were trained in a Skinner box to press for continuous water reinforcement. On the avoidance training day, Ss received a .01 sec., 5 ma shock (calibration resistance = 100 K) and were immediately removed from

the box. Shock occurred on the first bar press after S had been in the box for 20 sec. Three groups of six Ss each were tested for retention 1 min., 2 hr., or 8 hr. after the shock. Training and testing were carried out so that all Ss were deprived of water for 23 hr. prior to the last preshock training trial and to the postshock test of retention.

Results

The measure of retention was the number of presses during the last 10-min. preshock training trial minus the number of presses on the 10-min. test of retention. The mean difference scores plotted in Fig. 1 resulted in a significant U-shaped function ($F=5.36$, $p<.05$). The 1-min. group retained better than each of the other two groups ($p<.05$), and the 8-hr. group retained better than the 2-hr. group ($p<.05$).

EXPERIMENT 2

Procedure

Experiment 2 was similar to Experiment 1 except for the following differences. The 25 Ss were trained to drink from a spout. Water was not contingent on a bar press; however, the spout was located just above a large bar which was invariably depressed when Ss drank. Possible shock duration was lengthened to .1 sec. Three groups of five Ss each were returned to the box at the same intervals as used in Experiment 1, but an additional 10 Ss were tested 25 hr. following the shock.

Results

As demonstrated by Fig. 2, the 1-min., 8-hr., and 25-hr. groups all spent less time at the spout during the first 5 min. of the test of retention than the 2-hr.

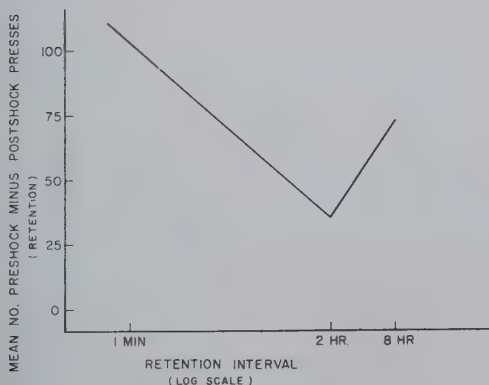


Fig. 1. Percent loss of pressing rate from preshock to postshock trials at different retention intervals.

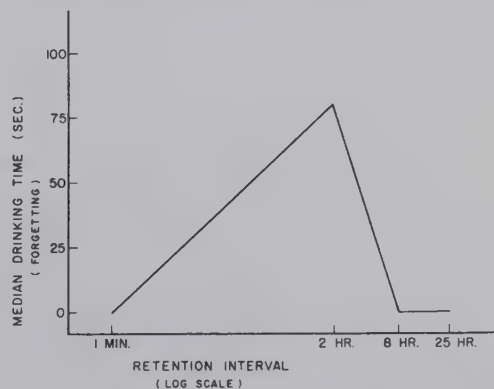


Fig. 2. Time spent drinking during the first 5 min. of the retention test for different acquisition-retention intervals.

group ($U=2$, $U=2$, $U=8$, $p<.05$). U tests were used to evaluate these differences since many of the Ss did not drink during the retention test.

DISCUSSION

In the one-trial avoidance situation, a decrease in fear invariably results in more responding and consequently in poorer shock retention. This is the case irrespective of whether the decrease in fear results in less motivation to avoid or in less freezing behavior. Therefore, since a U-shaped retention function was demonstrated after one-trial avoidance learning, it may be concluded that the lower extremum of the Kamin effect is related to a decrease in fear. If the Kamin effect were due to an increase in fear, retention would have been best rather than worst at 2 hr.

Since Ss were removed from the box immediately after being shocked, their avoidance training prior to the test of retention consisted of just one escape response. Since no prior avoidance response had been made, no warm-up factors could have affected avoidance performance on the test of retention. In Experiments 1 and 2, the Kamin effect was, thus, demonstrated without any effects of warm-up. This supports Kamin's 1963 finding that a monotonic warm-up decrement is not necessary in the production of a U-shaped retention function.

Cooper & Koppenaal (1964) showed that when one-trial avoidance training directly preceded a single electroconvulsive shock (ECS), there seemed to be little retention of the avoidance training 1 hr. later but good retention 24 hr. later. They concluded that an ECS only temporarily suppressed the avoidance habit, thus casting doubt on the consolidation interpretation of the effects of ECS. The consolidation theory implies a permanent impairment in retention. However, their experi-

mental design was not sensitive to performance changes in the controls, and in the light of Experiments 1 and 2 it is possible that the apparent recovery from ECS suppression reflects an increase in the strength of the avoidance habit from 1 to 24 hr. Supporting this view is the fact that in one of the Cooper and Koppenaal experiments the 24-hr. controls showed a slight but consistent tendency to retain better than their respective 1-hr. controls.

This criticism of Cooper and Koppenaal may have significance in a larger context since the one-trial avoidance task is used widely in ECS research. Until more is known about the retention function after one-trial avoidance learning, the present difficulties that seem to exist in the interpretation of the effects of ECS on this function may continue to increase.

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Notes

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2. Holder of a Canadian N.R.C. bursary.

Retroactive facilitative effects of ECS on learning an avoidance response in a two-choice situation¹

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Rats learned to avoid a place where they received grid shock to their feet when the grid shock was followed 10 sec. later by electroconvulsive shock. The avoidance learning was significantly greater than for rats that received only grid shock or only electroconvulsive shock.

Electroconvulsive shock (ECS) has been used extensively in animal learning studies in an attempt to clarify the role and time course of memory in learning. As ECS upsets neural processes in some way, rats given ECS following conditioning trials usually fail to learn the response, i.e., "retrograde amnesia." However, much of the evidence for this retrograde amnesia hypothesis has been shown to be equally compatible with an ECS avoidance hypothesis (Coons & Miller, 1960; Adams & Lewis, 1962a, b; McGaugh & Madsen, 1964). Under the assumption that ECS is an aversive stimulus, two conditioning hypotheses have been proposed to account for the fact that rats do learn an avoidance response that is followed by ECS. One notion (Coons & Miller, 1960) is that ECS may be a fear-inducing stimulus, while the other (Adams & Lewis, 1962a, b) is that the pairing of ECS with the experimental situation results in cue produced competing responses which effectively impair performance of the previously learned response. However the effects of ECS as a possible aversive stimulus have not been fully determined (cf. McGaugh & Madsen, 1964).

The present experiment was conducted in an attempt to examine the components of ECS, aversive or otherwise, and to test the retrograde amnesia hypothesis in a slightly different situation than heretofore employed.

Method

The experiment utilized a 2 by 2 design, in a two-choice situation, in which presence or absence of grid shock in the goal box was varied independently from place of the subsequent ECS treatment, inside or outside the goal box. In addition, there was a fifth comparison group which received grid shock but not ECS.

Fifty-nine male albino rats (100 to 120 days old) were given 24 pretest escape learning trials (four trials per day with an intertrial interval of approximately 1 hr.) from grid shock (0.9 ma) in the start box of a T-maze. Choice of goal arm to which S escaped was partly forced so that two right and two left turn responses were made on each training day. The T-maze was modified so that it had only a start box and two goal boxes, i.e., a T-maze with runways eliminated. The left goal arm was painted flat black and the right flat white, with the remainder, start box and intersection between

start and goal boxes, flat grey. Guillotine doors at the exit of the start box and at the entrance of the goal boxes were lowered to prevent retracing or to force turns during training when necessary. The grid floor of the start box and intersection was wired for electric current independent of the goal arm grids, allowing current to be turned on (or left off) in the goal boxes at any time after current was applied to the start box. Cut-down alligator clip ECS electrodes were briefly attached to S's ears following the first daily training trial.

Following training Ss were randomly assigned to one of five treatment groups: Group S—grid shock alone; Group EI—ECS alone inside the goal box; Group EO—ECS alone outside the goal box; Group SEI—grid shock followed by ECS inside the goal box; and Group SEO—grid shock followed by ECS outside the goal box. The above treatments were administered only when S entered the "incorrect" goal box. The latter was defined as the box that S entered on the first trial following the last training trial. Thus each S received his respective treatment on this trial and could avoid it on following (testing) trials only if he entered the opposite "correct" goal box. Testing lasted, one trial per day, for 24 trials following the first treatment trials. The grid shock (0.9 ma, for 4 sec.) was administered immediately after S entered the goal box. Each S remained in the goal box for 10 sec. after cessation of the grid shock. If S made a correct response, or was in a group not receiving grid shock, he merely remained inside the goal box for 14 sec. without receiving grid shock. For the groups receiving ECS (50 ma, for 200 msec.), it was given immediately after the 14 sec. in the goal box following an incorrect response. The ECS electrodes were always briefly attached to all Ss in each group regardless of whether ECS was to be administered or not.

Results and Discussion²

ECS induced paraplegia (seven casualties) necessitated the random elimination of normal Ss from the appropriate groups to equalize N across groups for statistical analyses. The data presented are from the 10 remaining Ss in each group. Figure 1 shows the percent correct performance in blocks of four trials for each group. The Ss in Groups SEI and SEO quickly learned to avoid the treatment box and continued to respond to the treatment free box throughout testing at a much higher level than the other groups. The curves of Groups EI and EO show only a gradual rise in performance. Group S fell between these two extremes. In terms of total percent avoidance responses, the

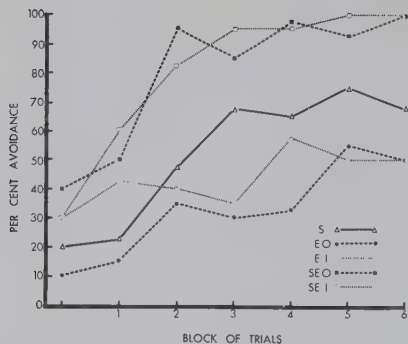


Fig. 1. Percentage of choices of non-treatment box for each group in four trial blocks. The first data points are the percent responses, on the first trial of the last training day, to the goal box subsequently defined as "correct."

groups from highest to lowest were ordered: SEI, SEO, S, EI, and EO, and the percentages were: 89, 87, 58, 46, and 36 respectively. An analysis of the arcsin of total percent avoidance responses of each S revealed highly significant differences among groups: $F=7.35, p<.001, df=4, 49$. The Duncan (1955) range test yielded significant differences between the comparisons of Groups SEI and SEO with all other groups but not between each other (i.e., SEI vs. S, $p<.05$; SEI vs. EI, $p<.01$; SEI vs. EO, $p<.001$; SEO vs. S, $p<.05$; SEO vs. EI, $p<.01$; SEO vs. EO, $p<.001$). The other comparisons, among Groups S, EI, and EO failed to reach significance.

The fact that Groups SEI and SEO had significantly more responses to the treatment free box than did any of the other groups indicates that ECS following grid shock in the goal box had a facilitative effect on avoidance learning. This result is incompatible with the ECS retrograde amnesia hypothesis. In this respect the results are in agreement with those of Coons & Miller (1960) although they used latency rather than choice as the response measure.

That Groups SEI and SEO had significantly higher avoidance levels than Group S indicates that the aversive

components of the treatment arm could not have been due to grid shock alone. Conversely the relative inferiority of Groups EI and EO in avoiding the treatment arm would indicate that the behavior in Groups SEI and SEO cannot be explained by ECS avoidance either. These findings argue against a simple ECS fear or a simple competing response hypothesis, i.e., that Groups EI and EO performed at such a consistently low level of ECS avoidance suggests that ECS itself is not a strong aversive stimulus (cf. McGaugh & Madsen, 1964) or that any fear responses it may produce do not readily become conditioned to innocuous conditions that precede it, or greatly interfere with responses that result in it. The lack of significant differences due to place of ECS administration does not agree with the results of Adams & Lewis (1962a, b) although situational differences and the ceiling effect of Groups SEI and SEO preclude comment on this discrepancy.

However the results do suggest some sort of conditioning process, whereby the grid shock is the CS, and ECS has the properties of an aversive UCS. This notion fits reasonably well with the high performance of the grid shock—ECS groups, assuming that the aversive factors of ECS are prominent only where a salient and/or "similar" CS is used. This study is, then, yet another indication that repeated ECS trials (within the response—ECS interval used) will not suffice as a test of the trace consolidation hypothesis of memory.

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Notes

1. Data herein were reported at the Midwestern Psychological Association meeting, St. Louis, 1964.
2. A pilot study duplicated the results of Groups SEO, EO and S.

Classical conditioning and extinction of the licking response in rats¹

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Data from an experimental group and a pseudoconditioning control group show that licking responses in rats can be classically conditioned and that this conditioning occurs within 60 trials and extinguishes rapidly when water reinforcement is removed.

The relative paucity of psychological research in the area of classical reward conditioning has been due largely to the difficulties attendant on the use of the salivary response, which requires complex measuring techniques and somewhat difficult operative procedures. Miller (1961) introduced a method used in classical conditioning for recording the licking response in the rat by means of an oral fistula, but again an operation was required and the animal had to be restrained. A simple technique has recently been developed (Deaux & Patten, 1964) for recording licks from a moving rat, and, as it involves neither operative procedures nor restraint, this method lends itself nicely to classical conditioning.

In our earlier study, this recording technique was used in an instrumental runway situation to measure the anticipatory goal response (r_g) which, according to Spence (1956), is a classical conditioned response evoked by stimulus cues at the beginning of the alley. In order for us to establish this licking measure as an operational reference for the r_g , it is therefore necessary to show that the measured response can be conditioned in the classical conditioning situation.

Method

The subjects (Ss) were 12 naive female hooded rats, approximately 120 days old, 9 of which were assigned to an experimental (conditioning) group and 3 to a control group. All Ss were deprived of water for 22 hr. preceding each session. Briefly, the recording technique consisted of the rat's wearing an elastic harness and a headgear which held a small drinking tube 1/8 in. in front of its mouth. An electric circuit through S detected each contact its tongue made with the tube, whether water was being presented or not. The only restraint on the rat was that caused by the harness and the polyethylene tubing through which the water reached the drinking tube.

During all the sessions, S was maintained on a 30 in. by 18 in. elevated platform, with the wires and polyethylene tubing suspended above it to prevent S from becoming entangled. The licking was recorded for all Ss during a 3 sec. period preceding the conditioned stimulus (CS) onset and during the first 3 sec. of the 5 sec. CS, which consisted of a 500 cps, 70 db tone and the light from a partially darkened 15 w. bulb. For Ss in the experimental group, the 3 sec. recording period during CS presentation terminated with the onset of the

unconditioned stimulus (UCS), which was the presentation of .075 ml. of water over the last 2 sec. of the CS. The control group's responses were recorded only on the CS-alone trials. For each trial the number of licks in the pre-CS period was subtracted from the number of licks in the 3 sec. period during the CS to give a score of the discriminated licking to the CS.

A pretraining session of 40 UCS-alone presentations was given to all Ss one day before acquisition. During the 3 days of acquisition training, the experimental group received 40 paired presentations of the CS and UCS per day, with randomized intertrial intervals of 50, 60, and 70 sec. with a mean of 60 sec. On the first day of extinction this group received 5 CS-UCS pairings followed by 30 CS-alone presentations. Fifteen more extinction trials were given the following day to check for spontaneous recovery; intertrial intervals were the same for extinction and acquisition sessions. The control Ss received 80 random presentations of the CS and the UCS (40 of each) per day with intertrial intervals of 25, 30, and 35 sec. with a mean of 30 sec. Since, with the difference measure employed, each S in the experimental group acted as its own control, it was felt sufficient to give the pseudoconditioning control Ss only the random CS and UCS presentations without following this with the CS-alone "extinction" trials.

Results and Discussion

Figure 1 presents the mean difference licking score for each S per trial plotted in blocks of 10 trials in

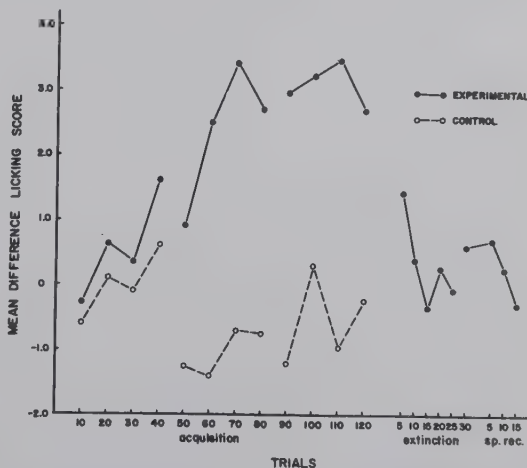


Fig. 1. Mean difference licking scores per trial for subjects in experimental and control groups over acquisition, extinction, and spontaneous recovery sessions.

acquisition and blocks of 5 trials in the extinction and spontaneous recovery sessions. It can be seen that for the experimental group the differential licking increases until the third day, where it levels off at a difference of about 3.2 responses, which was found to be statistically significant, $t=10.6$; $p < .001$. On day 3 of acquisition, the mean number of responses per trial per experimental S was 2.2 during the pre-CS period and 5.4 during the CS-UCS interval. It is clear that classical conditioning of the licking response did occur and that an apparent asymptote was reached after approximately 70 trials. The control Ss do not show this increased licking to the CS but rather have a negative mean difference score of licking on days 2 and 3, indicating that there was some inhibition of responding during the CS.

The data from the extinction sessions show that extinction was rapid with practically no anticipatory licking occurring after 15 CS-alone trials. During the first extinction session the mean number of responses

per trial per S was 1.3 during the pre-CS period and 1.7 during the CS-UCS interval. The second day's data show very little spontaneous recovery, with less than one response per trial per S in each 3 sec. recording period. The rapidity of extinction differs from the findings of previous subhuman classical conditioning studies as does the absence of spontaneous recovery.

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Notes

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2. Now at the University of Richmond.

Generalization gradients from "reaction time" or latencies of the white rat to visual brightness¹

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Presentations of a light stimulus S^D (milk-reinforced), interspersed with varying S^Δ light stimuli (not reinforced), yielded generalization gradients of response latency ("reaction time") for 2 albino rats. Gradients also appeared when "failure to respond" was used as the behavioral measure. The latter type of gradient changed with continued training, first in the direction of indicating increased discriminative sensitivity, and then toward less sensitivity.

Although "reaction time" is generally studied with humans as S s, lower organisms can also be used provided the verbal instructional variables are replaced by appropriate non-verbal discriminative stimuli and correlated operant reinforcement contingencies. Stebbins & Lanson (1961) have in this way studied some hitherto unexplored relations between latency and theoretically important parameters such as amount and schedule of reinforcement (Stebbins, 1962; Stebbins & Lanson, 1962). The present paper employs a procedure similar to theirs to secure from rats generalization gradients for visual brightness.

METHOD

Subjects

Two male albino rats, Charles River CD, approximately 100 days old on arrival in the laboratory.

Apparatus

The experimental chamber was a modified Lehigh Valley Electronics unit, Model No. 1316. It contained as the experimental operandum a plastic translucent hinged panel mounted on one wall of the chamber. This panel, which required 10 gm pressure for microswitch closure, was transilluminated by means of a Kodak Carousel slide projector outside the chamber. The brightness of this panel could be varied in 13 steps (6 S^Δ values on either side of S^D) from 0.30 to 3.75 log ft. lamberts by neutral density filters used as slides in the projector. The experimental chamber was illuminated in no other way. The blower in the projector, another mounted in the chamber itself, and a 7-1/2 in. separate fan behind both projector and chamber provided ventilation and some measure of sound masking. The experiment was programmed by transistorized digital-logic circuitry. Data were recorded on counters, and print tape.

Procedure

The animals were reduced to 75% $\pm$ 5% of their individual ad libitum weights and subsequently kept at that same percentage of the weight of a third animal which served as a standard and which was maintained throughout the experiment on ad lib feeding. Reinforce-

ment (S^R) following a panel press response was 3 sec. of access to a dipper coming up from a reservoir and holding approximately 0.02 cc of a 50% mixture by volume of condensed milk (Borden's Eagle Brand) and water. The training and testing procedures can be described in terms of cycles as follows: (a) A cycle began with the experimental chamber dark and quiet. The first panel press response turned on a 1k cps, approximately 40 db (re. 0.0002 dynes/cm²) tone; if a second response occurred within the next 5 sec., the tone went off, returning the animal to the original dark-quiet condition which then remained in effect until another response was made which restored the tone, following which, if another response were again made within 5 sec., the dark-quiet condition was again restored, and so on until the tone-producing response and the next response were separated by at least 5 sec. When the tone was on at least for 5 sec., the next component of the cycle came into effect. (b) This second component was initiated by onset of a light which continued with the tone until both were terminated together. If the light in that cycle was an S^D presentation, the first response in its presence was reinforced and also terminated the tone-light, thus placing the animal in the dark-quiet condition of the next cycle; if the light in that cycle was any of the S^Δ values, no response during it was reinforced and the light continued for its full scheduled duration (10 sec.) in which any number of nonreinforced responses could be made, the tone-light being then terminated and the animal placed in the dark-quiet condition of the next cycle.

The following features of this schedule may be noted; having the animal produce the tone of each cycle helped insure its closeness to the response key when the light came on; the re-cycling of the dark-quiet phase served to cut down on "false or anticipatory" reactions to the next light stimuli; the S^D , if not responded to, was the same length (10 sec.) as each S^Δ , so that the "stimulus hold" period imposed on the response no different requirement in S^D than in S^Δ ; the 10 sec. maximum duration of light acted to "shape" a short response latency; a free-operant situation prevailed at all times; the re-appearances of S^D intermingled with S^Δ s provided a schedule of behavior maintenance as opposed to generalization testing in extinction.

The S^D brightness intensity was 2.1 log ft. lamberts. Rats were first trained to this value only, for four hourly sessions on a regular reinforcement schedule, but with the 2-response sequence as described above in effect. Beginning with the fifth session, the twelve

S^A stimulus values were added and, together with the S^D , were exhibited to the animal in mixed order. In each session, frequency of S^D presentation approximately equalled the total of all S^A occurrences. The principal data taken were the latencies of the first response to each S^A and S^D presentation.

Results and Discussion

Figure 1A shows both rats' latencies averaged for each of the 13 test brightnesses. Generalization gradients emerge with the present procedure, although the weakness of the albino's visual brightness discriminative system may perhaps account for the shallow curvature of the gradient. A 5X change in the $1/\text{latency}$ is noted, but this occurs over a range of approximately 3.5 log units of brightness. The reversal in the function at 3.0 log ft. lamberts adds a complexity to the gradient form. The control data shown in Fig. 2 indicate that this added complexity does not arise from the independent effects of absolute light stimulus intensity on response latency. Thus, although a number of studies (e.g. Chocolle, 1940; Hull, 1951) have shown a relation of this sort, there is no reason to believe that it holds under our present conditions, since latency is about the same over the intensity range used when reinforcement conditions are equal for all intensities.

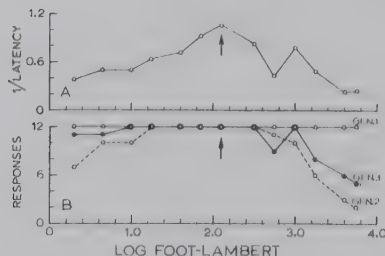


Fig. 1. Panel A shows reciprocals of mean latencies of both animals at each stimulus intensity. Each point is the mean of both animals' mean response latency to each stimulus averaged across the last 11 sessions. S^D is indicated by the arrow. Panel B shows total number of times on which a latency was recorded (up to 10 sec.) for both animals, each of which had 6 opportunities to respond to each S^A stimulus in each of the sessions plotted. The S^D value (arrow) occurred with a frequency approximately equal to the total of all S^A s and the point plotted here may be understood to indicate not 12 opportunities, but rather that no presentation of S^D ever yielded a failure to respond within a 10 sec. interval. "Gen 1" indicates the first session of testing during which each rat received his first 6 exposures to the range of S^A ; "Gen 2," six exposures of each rat to the stimulus range during the middle of the 32 training sessions; and "Gen 3," the last 6 exposures of each rat in the 32nd training session.

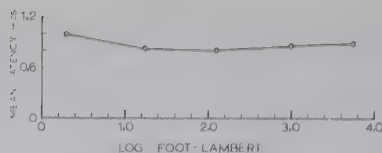


Fig. 2. Mean values for 1024 latencies from one rat to each of 5 stimulus intensities. Reinforcement occurred for each response at each intensity. Each intensity was in effect for two entire sessions on two different days; during each session 512 latencies were recorded. The order of use of intensities was randomized.

A characteristic of the gradient also seen in Fig. 1A is an asymmetry characterized by longer latencies at the higher stimulus intensities. Although our brightnesses are higher than those reported as aversive levels (e.g. Keller, 1941; Kaplan, 1952), our own rats responded indifferently to them during initial sessions (some indication of this is seen in the function labelled "Gen 1" of Fig. 1B). Longer latencies at high S^A values develop only after some appreciable amount of exposure to the stimuli (vide Fig. 1B).

The number of "failures to respond" to test stimuli generally increased as training progressed, especially at the ends of the stimulus range, and these data may themselves be used to plot a generalization gradient (c.f. Winograd, Cohen, & Cole, 1965). Such gradients from our data are plotted in Fig. 1B taken at three different stages of training. These appear first to sharpen, and later to flatten somewhat, with training time.

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Note

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Electrodermal responses in the sociopath¹

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Sociopathic Ss were compared to a non-sociopathic control group with respect to base level and magnitude and frequency of elicited and emitted GSRs. The sociopathic Ss' GSR patterns did not differ significantly from controls on the measures of base level and elicited GSR. The sociopaths' rate of spontaneous GSR emission was not significantly altered by the introduction of shock anticipation and was significantly lower than controls under the same shock threat stress condition.

The behavior of the sociopath, especially with respect to emotionality, is paradoxical. Among other symptoms (Cleckley, 1959), the sociopath appears to be free of neurotic, or even normal, anxiety and often seems at ease in situations which would make the average person tense and apprehensive. Fox & Lippert (1963), using a technique developed by Lacey (1963, 1958), have demonstrated that sociopathic Ss have a lower rate of GSR fluctuations, with respect to non-sociopathic controls, when tested under resting conditions involving low stimulation levels. The present study is an extension attempting to investigate the autonomic functioning of the sociopath under conditions of controlled direct stimulation and stress.

Method

Two groups of 21 white, male, adolescent Ss were selected from the detention unit of the Hamilton County (Ohio) Juvenile Court. The Ss in one group were diagnosed sociopathic personality disturbance, anti-social type (SPD group); Ss in the other group were diagnosed adjustment reaction of adolescence with neither history nor current evidence of sociopathy (AR group).

Ss were taken individually to the experimental chamber, were seated in a comfortable chair, and had zinc palmer GSR electrodes attached to their hands. Each experimental session was of 1 hr.'s duration divided into five periods as follow: (1) 20 min. adaptation period during which the subject was allowed to acclimate to the surroundings, (2) 10 min. rest period, (3) 10 min. stimulation period during which randomly spaced strong visual (Strobotac light) and auditory (ringing telephone) stimuli were presented, (4) 10 min. "stress" period during which pseudo-electrodes were taped to the S's right calf (S was told that in exactly 10 min. he would receive a strong but harmless shock. A large clock was visible to the S so that the temporal proximity of the supposed shock could be observed. No shock was administered), (5) 10 min. post-experimental adaptation in which the leg electrodes were removed and S was allowed to rest without stimulation. GSR recordings (via Fels Dermohmmeter) were taken continuously throughout periods 2 through 5. These recordings were scored blind for absolute skin resistance,

frequency of spontaneous GSR changes of 600 ohms or more, and the magnitude of elicited GSRs.

All recordings and stimulus control equipment was housed in an adjacent room from which S was observed through a one-way mirror.

Results

With respect to basal conductance levels and magnitude of GSRs elicited by specific stimuli, the Ss in both groups produced quite similar records. No statistically significant differences in basal conductance between groups was demonstrated. ($F=1.16$; $df=1/40$; $p>.05$). The magnitude of GSRs elicited by the photic and aural stimuli were evaluated by converting absolute conductance changes to "lability scores" (Lacey, 1956). The mean lability scores for the SPD group and AR group were 52.1 and 51.7, respectively. The difference is not statistically significant ($\alpha=.05$).

Some differences in automatic activity between the AR and SPD groups were indicated in measurements other than basal conductance level, viz., (1) spontaneous GSR emissions, (2) anticipatory reactions, and (3) recovery.

Figure 1 shows indices of spontaneous GSR emission for both groups across experimental treatments. Or-

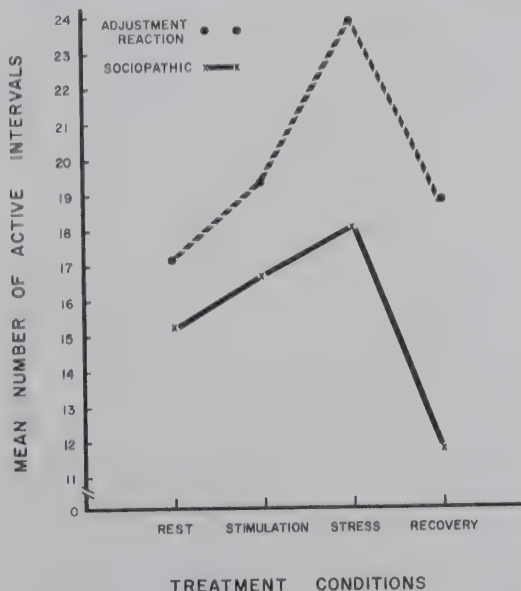


Fig. 1. Mean number of 20-sec. time intervals containing one or more spontaneous GSR drops of at least 600 ohms as a function of experimental periods.

dinate values are mean number of "active intervals" which are 20-sec. time segments containing one or more spontaneous decrease in resistance of 600 ohms or more.

The differences between group means are not statistically significant for the rest and stimulation periods ($\alpha = .05$). The mean number of active intervals during the stress ($\bar{X}_{AR} = 23.86$; $\bar{X}_{SPD} = 18.14$) and recovery ($\bar{X}_{AR} = 18.17$; $\bar{X}_{SPD} = 11.81$) periods were significantly different (Neuman-Keuls) with $p < .05$ and $p < .01$ respectively. At the end of the stress period, i.e., when the clock in S's chamber indicated shock was due, 12 members of the AR group displayed abrupt drops in skin resistance. None of the SPD group exhibited such an anticipatory response.

The most striking aspect of the SPD group's spontaneous GSR record was observed during the recovery period when the mean number of active intervals declined to 11.81 (see Fig. 1). This mean was significantly ($p < .01$) lower than the AR group mean ($\bar{X} = 18.71$) for the same experimental period, and even significantly ($p < .05$) lower than was exhibited by the SPD group, itself, during the pre-stimulation rest period.

Discussion

The presence of the sociopathic syndrome does not appear to affect basal skin resistance. The magnitude of elicited GSRs also seems quite similar for sociopathic and control Ss. With respect to spontaneous GSR changes sociopathic Ss differ from non-sociopathic controls in three major respects, (1) the rate of spontaneous GSR emissions is significantly lower than for non-sociopathic controls under conditions of shock threat stress, (2) sociopathic Ss do not emit spontaneous resistance decrements as an anticipatory response to shock, (3)

the sociopathic Ss return more rapidly, and to a lower level, of spontaneous GSR emission once the experimental manipulations are finished. It would seem that elicited autonomic responses for the sociopath are rather rigidly tied to concrete, objective events in the environment. He shows less tendency to respond in anticipation of future shock or to continue to respond after stimulation has passed. The internal mechanisms controlling spontaneous GSR appear for the sociopath to be less affected by stress associated with the expectancy of pain.

The results of this investigation suggest that the electrodermal regulatory system of sociopathic Ss is such that it responds only to concrete external events and that diffuse states of heightened "activation," commonly associated with emotions such as anxiety or apprehension, occur at a lower level than in control Ss. Such a pattern of autonomic functioning is consistent with clinical observations of sociopathic behavior.

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Note

1. The research reported here is a portion of the senior author's Ph.D. dissertation, University of Cincinnati, 1965.

Higher-order conditioning of fear (CER)¹

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Stable higher-order conditioning of an emotional response was found in a vast majority of rats given an extension of the CER suppression procedure. The phenomenon was demonstrated under a variety of conditions and frequently took the form of total suppression in the presence of a stimulus which had never been paired with shock.

Recently McAllister & McAllister (1964) have demonstrated that fear may be conditioned at the second order in rats tested in a hurdle-jumping situation. Working independently of the McAllisters but sharing their concern over the lack of convincing data on this neglected phenomenon, I have been studying higher-order conditioning of fear in the CER suppression situation. With this technique I have found that second-order conditioning of an emotional response appears in a particularly clear and stable form in rats over a fairly wide range of experimental conditions. In this report I will summarize the general findings of the first four of six higher-order CER conditioning studies conducted in the past three years.²

Method

Standard Gerbrands Model C rat test chambers, controlled by remote automatic programming devices, were used. The Ss were 52 adult male albino rats of the Sprague-Dawley-Holtzman strain.

In accordance with the usual suppression procedures, lever-pressing was maintained on a variable-interval reinforcement schedule on which were superimposed stimulus presentations constituted by the various conditioned stimuli (CSs) and the unconditioned stimulus (UCS). CSs used were a medium-intensity 800-cycle tone generated by a Signal Corps TG-34-A Keyer, a bare type 313 pilot light located above the top lid of the chamber, a 1/sec. pulsating buzzer, and a 6.8/sec. clicking sound produced by a Foringer 1293 Click Generator. The UCS was grid shock, delivered by a Grason-Stadler E1064GS Shock Generator.

Within a given study, experimental and control Ss underwent the same training and testing procedures up to the beginning of the second-order conditioning stage. After stable baselines of pressing were achieved, three to five unpaired test presentations of each of the CSs were given (one per day in many Ss, to rule out sensory preconditioning) as a check on their initial fear-eliciting properties and as a means of adapting out novelty effects. Following these test presentations the first-order conditioning phase was begun, with one of the neutral stimuli (CS₁) paired with the shock UCS, usually with the shock terminating a CS₁ presentation. Shock durations were .5 or 1 sec. and CS₁ durations ranged from 1 to 2 min. Shock intensities ranged from nominal

values of .5 to 3 ma. Sessions in which no stimulus presentations took place were frequently interspersed among first-order conditioning sessions to keep the rate of lever pressing near that of preshock days. Following the CS₁-UCS trials, additional sessions were devoted to testing for reinstated novelty effects and for stimulus generalization of the first-order conditioning to CS₂ and CS₃ (presented alone); in most cases only very slight or nonexistent suppression tendencies were found on these test trials.

The second-order conditioning trials were given to the experimental Ss in paired presentations with the onset of CS₂ preceding the onset of CS₁ and with the shock omitted. Control Ss received equal numbers and durations of presentations of the same stimuli, but in a backward order 2 to 12 min. apart. The CS₂-CS₁ temporal arrangements in second-order conditioning included pairings in which the two stimuli were overlapping (60-30-30 and 60-45-15) and nonoverlapping (30-30-30, 60-60-30, and 90-90-10), where the numbers in each of these designations refer to the duration in seconds of CS₂, the time between the onsets of CS₂ and CS₁, and the CS₁ duration, respectively. Most of the possible combinations of the four neutral stimuli were represented in the CS₂-CS₁ presentations and the scheduling of trials varied from one trial per daily 20-min. session to 12 trials per 80-min. session.

Measures of suppression were based on the number (f_d) of lever responses occurring during a stimulus presentation in relation to the number (f_p) occurring in the immediately preceding baseline period of equal duration. The suppression ratio was defined as $f_d/(f_d + f_p)$.

Results

Second-order conditioning was readily obtained in all four studies. Of 36 rats given the experimental procedure, 32 displayed second-order conditioning in the form of at least partial and consistent suppression in the presence of CS₂ alone, a stimulus which had never been paired with shock. Of these conditioned animals, 13 showed complete suppression to CS₂ on at least two trials and usually for many consecutive trials. In contrast, none of the 16 control Ss exhibited even partial suppression consistently, and it was typical of the controls to show a small increase in their suppression ratios from the starting level of about .5. In addition, when eight control rats were given paired CS₂-CS₁ or CS₃-CS₁ trials following this performance on unpaired trials, six of them showed clearcut evidence of second-order conditioning, bringing the record to 38 successes and 6 failures in 44 second-order conditioning attempts. Two of four Ss in which third-order conditioning was

attempted showed partial suppression having enough consistency to warrant the conclusion that third-order conditioning is attainable in this situation.

Representative individual curves of experimental and control performance are shown in Fig. 1. These curves were taken from an experiment in which the 90-90-10 temporal arrangement was employed in the second- and third-order stages and trials were given at the rate of one per day. The curves are representative in showing: (a) the basic difference between experimental and control Ss in the second-order phase, (b) the results of two attempts at third-order conditioning, (c) the rapidity with which second-order conditioning may be obtained with an auditory CS₁, and (d) the relative difficulty of obtaining higher-order conditioning when the second-occurring CS is a visual stimulus (all but one of the second- and third-order failures had a light as the second-occurring stimulus). The high resistance to extinction of the fear to CS₁ revealed in all six panels is typical of one-trial-per-day and four-trial-per-day studies.

The typical form of the suppression pattern in instances of highly successful second-order conditioning may be seen in Fig. 2, which shows the cumulative lever response records for the first eight CS₂-CS₁ trials of a single S. In indicating that lever responses tend to drop out in the earliest portion of the CS₂ presentation first, this S's record was characteristic of about three-fourths of the second-order conditioned Ss.

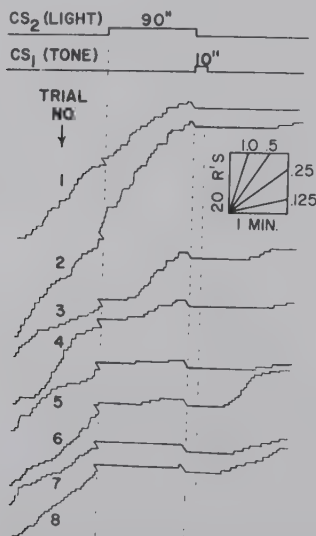


Fig. 2. Cumulative response records obtained on the first 8 second-order conditioning trials given to a single S in 8 successive daily sessions.

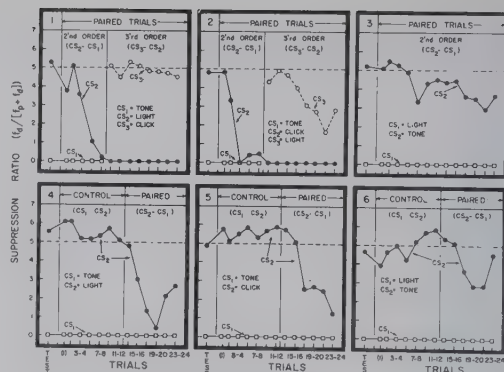


Fig. 1. Performance curves of 6 Ss showing conditioning of suppression at the second-order ("paired" phases of all 6 panels) and at the third-order (panel 2, failure of attempt in panel 1), and typical control performance ("control" phases, panels 4-6).

In general, second-order conditioning showed the greatest stability and strength when first-order shock intensity was high, CS₂ duration in the second-order stage was long in relation to CS₁ duration, CS₁ was an auditory stimulus, and conditioning trials were widely distributed. In view of the suggestion in McAllister & McAllister's (1964) footnote that the demonstration of second-order conditioning in the hurdling-jumping situation may be difficult to obtain unless first- and second-order trials are intermixed and criterion testing is done immediately after the intermixed trials, the present finding of stable conditioning on a one-trial-per-day regimen involving no intermixture offers considerable comfort to those who believe in the authenticity and importance of this phenomenon.

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Notes

- Supported by grant G-13265 from the National Science Foundation and grants M-4991 and FR-0167 from the National Institutes of Health.
- Following the four successful demonstrational studies summarized here, I found little or no second-order suppression in the 24 Ss of the fifth study. Though other procedural differences may have been responsible, this anomaly seems to have been due to excessive exposure to the CS₂ when presented alone in pretests prior to the first-order stage and in generalization tests between the first- and second-order stages—there were approximately six times as many test presentations as in the studies reported here. The second-order conditioning phenomenon was recaptured in a sixth study, in which the number of test presentations was returned to the necessary minimum.

Distribution of practice in the classical conditioning of planarians^{1, 2, 3}

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Eighty Ss were divided into four groups receiving training conditions of either light, shock, light paired with shock, or neither light nor shock. Half of each group were given trials 30 sec. apart and the remainder were given trials 60 sec. apart. Conditioning occurred only among Ss given paired light and shock with spaced training producing significantly greater conditioning. Half of all Ss were then given either massed or spaced extinction trials. Massing and spacing of acquisition trials were found to be of more significant influence upon rate of extinction than were the massing and spacing of extinction trials.

The present problem was designed to study the effect of massed and spaced trials upon the classical conditioning of planarians. Cornwell (1960) appears to have been the first to be interested in such a problem. His results indicated that distribution of practice was not an important variable and that the occurrence of a conditional response may have been due to sensitization since response frequency was independent of the temporal contiguity of the light and shock during conditioning. Cornwell used a distribution of trials that were essentially all massed. The present study, therefore, employed control groups for sensitization and a clearer separation between massed and spaced trials.

Method

Eighty Ss (*Dugesia doratocephala*) were divided into four groups receiving training conditions of either light (L), shock (S), an experimental group in which light was paired with shock (E), or neither light nor shock (NLNS). The apparatus used was similar to that described by McConnell, Cornwell, & Clay (1960). Half of the Ss in each group were given massed (M) trials having an intertrial interval of approximately 30 sec., and the remainder had spaced trials (S) with an interval of approximately 60 sec. Since no S was given a trial unless gliding or moving in a straight path the intertrial intervals were actually between 20-40 sec. and 50-70 sec. Ss were given 150 consecutive acquisition trials. On any given trial the duration of light presentation was 3 sec., and the duration of shock presentation was 1 sec. In the group receiving paired light-shock (E), the stimuli overlapped during the final second. Following acquisition training each of the groups were given an immediate 25 extinction trials to light presentation alone. Each of the groups were further subdivided so that half received massed (M) and half received spaced (S) extinction trials. The occurrence of turning response and of body contractions was noted during the presentation of each trial.

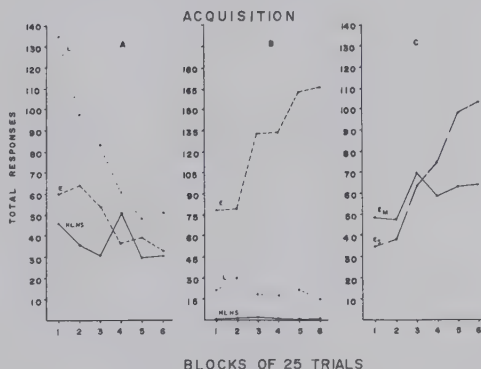


Fig. 1. Acquisition data for (A) turning responses (B) body contractions, and (C) body contractions among experimental subgroups.

Results and Discussion

From the acquisition curves it may be seen that there was a progressive decline in turning responses (Fig. 1A) although the number of turning responses in the light control (L) group was initially very high. This is interpreted as an indication that the level of illumination employed was not a wholly neutral stimulus even though there appeared to be adaptation to the light stimulus by the end of the acquisition trials. Differences between these three groups (L, E, NLNS) were non-significant. Examination of the data on body contractions during acquisition (Fig. 1B) shows a low rate of response in both the L group and the NLNS group with a pronounced increase in response rate in the E group. These differences are significant at beyond the 1% level. During acquisition no record was kept of turning responses for the S group, but body contractions occurred on every trial.

The acquisition curves for the E subgroups receiving massed and spaced trials are shown in Fig. 1C. The group receiving spaced trials had a terminal 41% body contractions as contrasted to 26% in the group receiving massed trials. An analysis of variance shows these groups to be significantly different at beyond the 5% level.

The extinction data are shown in Fig. 2. It can be observed that the frequency of turning responses (Fig. 2A) continues to drop in all groups. The differences between groups were not significant. During extinction the frequency of body contractions in the E group (Fig. 2B) were, however, significantly different from the other three groups. The breakdown of massed-

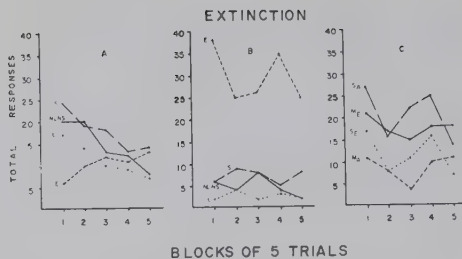


Fig. 2. Extinction data for (A) turning responses (B) body contractions, and (C) body contractions among experimental subgroups.

spaced conditions of acquisition as compared to the massed-spaced conditions of extinction is shown in Fig. 2C. The conditions of acquisition produced greater effects than the conditions of extinction in that all E subgroups receiving spaced acquisition trials are significantly different from all subgroups receiving massed acquisition trials whereas none of the subgroups receiving differential distribution of trials during extinction were significantly different from one another.

A sample of the data taken from the E group, for both acquisition and extinction, was independently judged. The resultant reliability coefficient was .96.

In summary, conditioning occurred only among Ss receiving paired light and shock and only for the meas-

ure of body contractions. The spaced training procedure produced a significantly larger number of conditioned responses than did the massed training procedure. Massing and spacing of acquisition trials were found to have a more significant effect upon rate of extinction than massing and spacing of extinction trials. It is to be noted that Ss of the present experiment demonstrated considerable resistance to extinction compared to that reported by Baxter & Kimmel (1963). It appears that the generalization concerning the relative efficacy of distributed practice as compared to massed practice applies to the lowly worm as well as to the higher vertebrates.

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Notes

1. This research was supported in part by a grant from the Florida State University Research Council.
2. The statistical analyses were made possible in part by NSF Grant (No. GP671) to the Florida State University Computation Center.
3. This research is taken from a Master's thesis earned by the second author. A portion of the research was presented at the 1964 American Psychological Association meeting by the senior author.

The response shift phenomenon in discrimination learning set¹

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A response-shift effect was exhibited by monkeys trained on a modified discrimination learning set, under conditions in which neither object to be discriminated had been previously displaced. This example of the effect therefore could not depend on any tendency of the monkeys to investigate non-displaced objects. It is suggested that the present effect might have its origin in a postulated tendency of monkeys to retain irrelevant but rewarded first trial Hypotheses compared to a tendency to replace irrelevant, nonrewarded first trial Hypotheses.

Moss & Harlow (1947) first noted the tendency of monkeys to make more errors following a Trial 1 reward than following a Trial 1 nonreward in object discrimination learning set (ODLS). This tendency was later termed "response shift" and was given the status of an "error factor" by Harlow (i.e., an error-producing response pattern). It was also theorized (e.g., Harlow, 1959) to result from a postulated tendency of the monkey to explore or investigate both objects in a discrimination problem.

The purpose of this paper is to present an instance of the response shift phenomenon obtained under conditions in which the exploratory tendency could not operate. This instance occurred unexpectedly in an experiment dealing with hypothesis learning in the monkey (to be reported elsewhere), and has led to the formulation of an alternate explanation of the response shift effect.

Method

Eight rhesus monkeys, 2 to 4 years of age, and without prior ODLS, were tested in the Wisconsin General Test Apparatus or WGTA (Harlow, 1949), using a formboard with two foodwells 12 in apart. Ss were extensively adapted to take food from the formboard and were then pretrained to displace objects using insoluble problems.

Next, Ss were trained for 32 sessions, each of eight six-trial discrimination problems (Phase I). The problems were designed to train one group of 4 Ss (Group R) on the Hypothesis or H (Levine, 1959, 1963) of "win-stay-on-object" and another group of 4 Ss (Group N) on "lose-shift-to-other-object." To do this, two new objects were introduced on Trial 1 of each problem. One of these objects then recurred on each of the following five trials, paired each time with a new object. For Group R the recurring object of each problem was always rewarded and the nonrecurring objects were not rewarded. For Group N, the recurring object of each problem was never rewarded, and the nonrecurring objects were always rewarded. Within each group, two further treatment conditions were differentiated, namely

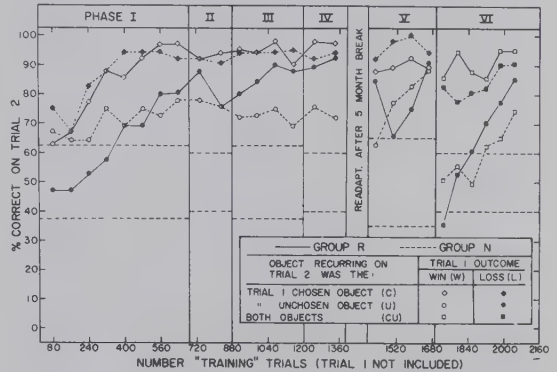


Fig. 1. Performance of Trial 2. throughout the experiment.

whether on Trial 1 the S was rewarded (i.e., "won," W) or not (i.e., "lost," L), and whether the recurring object was that chosen (C) or unchosen (U) on Trial 1. By this training procedure, the correct Hs of "win-stay" (Group R) or "lose-shift" (Group N) could be utilized on Trial 2, given a C condition. Additionally, correct Hs of "approach-recurring-object" (Group R) or "avoid-recurring-object" (Group N) could be used given either a C or a U condition.

Subsequently, the Ss were trained for 16 sessions (Phase II) exactly as in Phase I except that test trials were substituted for training trials on six of the Trial 2's and six of the Trial 6's within each 48-Trial session. On these test trials, both objects were baited and the reverse of the usual object recurred paired with a new object. A new problem was begun immediately following each test trial. Ss were next retrained for 16 sessions (Phase III) exactly as in Phase I. Phase IV, of 16 sessions, was then presented exactly as was Phase II except that on the test trials both objects of the immediately preceding trial recurred. The results on these Phase II and IV test trials will be reported elsewhere. Finally, following a break of 5 months, the Ss were retrained for 16 sessions in Phase V as in Phase I. Then 24 sessions were presented (Phase VI), each consisting entirely of 16 three-trial problems of the usual ODLS type (both objects of Trial 1 of a problem recurring on both subsequent trials).

Results

The relevant results consist of the Trial 2 performance on the training trials (Fig. 1). The two upper curves (rhombic points) for Phases I-V represent C conditions, in which two correct Hs were simultaneously

available to each group. Performance quickly approached maximum, and response shift appeared only at the very beginning of the C conditions, in the form of a slight performance superiority following a nonrewarded Trial 1.

The two lower curves (circle points) of Phases I-V represent the U conditions, in which only one correct H was available to each group. Those animals rewarded on Trial 1 (win) performed at 60-70% correct throughout, whereas those animals not rewarded on Trial 1 (loss) improved from chance to 90% correct by the end of Phase IV. Response shift appears as the difference between the solid circle and open circle curves from Phases II through IV. Despite the fact that these are between-group curves, these data parallel those of previous studies using regular ODLs (e.g., Davis et al, 1953; Riopelle, 1953; Behar, 1961).

It is clear that the present response shift cannot be explained as an exploratory tendency toward the non-displaced object, since in the U conditions neither of the two objects presented to the monkey on Trial 2 had been previously displaced. Accordingly, a new explanation for response shift has been devised which is general enough to be applicable both to the present effect and to response shift observed in regular ODLs.

First, assume that the monkey enters Trial 1 of a problem with some H, where the H is defined as a mediating process determining the response. Next, assume that if reward is obtained, the H is confirmed and therefore retained, but if reward is not obtained, the H is rejected and another H chosen. Such processes have been reported (Levine, 1964) for the human.

Now, consider the case in which the Trial 1 H is irrelevant. If it is rewarded and therefore retained, the monkey will make 50% errors on Trial 2. However, if it is not rewarded and is therefore rejected, the monkey will choose a new H. As learning progresses, this new H will tend to be the correct one. Thus, the monkey will tend to make fewer errors on Trial 2. These processes may be summarized by saying that the monkey retains error factors given a Trial 1 reward, but learns to abandon error factors for the correct H given a Trial 1 nonreward.

If the above explanation is valid, then only those instances in which the monkeys begin a problem with an irrelevant H (an error factor) would give rise to the response shift effect. Furthermore, this effect cannot begin to appear until the correct H or Hs begin to be available for choice on Trial 2, accounting for the absence of response shift early in ODLs. Additionally, response shift could only be manifested so long as the monkeys continued to use irrelevant Hs on Trial 1. This continued use of irrelevant Hs seems possible since the correct Hs depend on the reward outcome (or

also in the present experiment on the object recurrence) and the correct Hs are therefore not available prior to the Trial 1 choice.

From this line of reasoning, the development of learning set could be regarded as requiring the suppression of Trial 1, preoutcome Hs, and the response shift data then suggest that this suppression occurs most readily if nonreward occurs on Trial 1. If such suppression finally began to occur following Trial 1 reward, then performance following rewarded first trials would approach maximum and the response shift phenomenon would disappear.

This last event occurred in the present data (Fig. 1, Phase V, dotted line-open circle curve) when performance following a rewarded Trial 1 increased to a final level in excess of 90% correct. (The drop and recovery of the concurrent solid line-solid circle curve appeared to represent the adverse reaction of two animals to a change in experimenters.)

In the following Phase VI, in which both objects of a problem recurred on every trial, the Group R monkeys now learned "lose-shift-to-other-object" at about the same rate as the Group N monkeys learned "win-stay-on-object," and although the response shift tendency reappeared, it was not statistically significant. Furthermore, the upper pair of curves in Phase VI, for the conditions permitting the monkeys to utilize their previously learned Hs ("win-stay-on-object" for Group R and "lose-shift-to-other-object" for Group N) exhibited no significant difference and no response shift effect. These monkeys therefore eventually learned to deal with Trial 1 reward, and the response shift effect appeared to be a transitory phenomenon in the development of the learning set.

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Note

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Yeast ribonucleic acid: Effects on learned behavior in the rat¹

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Rats chronically treated with yeast ribonucleic acid showed enhanced acquisition of an escape response, thus replicating a previously reported effect. The nature of the enhancement, however, as well as the results from a food-rewarded discrimination task, does not suggest that yeast ribonucleic acid improves the learning or memory processes in the rat.

There are few studies in which learning or memory in animals has reportedly been enhanced by a pharmacological agent. A recent investigation by Cook, Davidson, Davis, Green, & Fellows (1963) employing yeast ribonucleic acid, has received considerable attention, not only because it apparently illustrates such an enhancement, but also because of the implications it may have for recent theories (e.g. Hyden, 1964; Gaito, 1963; Landauer, 1964) concerning the role of nucleic acids in experiential memory.

Cook et al compared the escape behavior of rats who had received 28 or 53 daily, intraperitoneal injections of yeast RNA, with that of saline-treated control animals. A conditioning trial involved placing S on a grid floor and then simultaneously presenting a buzzer and an electric shock through the floor. The stimuli terminated on such trials after 30 sec. or when S responded by climbing a vertical pole suspended above the center of the floor. RNA injected Ss took fewer trials to adopt a consistent pole-climbing response to the shock, and evidenced shorter response latencies than control Ss. Furthermore, RNA-treated Ss were more likely to respond on trials when the buzzer was presented alone, either when interspersed with shock-buzzer trials or during a block of such (extinction) trials.

The present experiments were designed to further clarify the effects of yeast RNA on learned behavior in the rat.

Experiment I

An attempt was made to replicate the Cook et al experiment under as identical conditions (Cook & Weidley, 1957; Cook, Davidson, Davis, Green, & Fellows, 1963) as possible. Initial work indicated, however, that in our apparatus, with the same nominal shock intensity employed by Cook et al (.8 ma), all Ss, regardless of their injection history, acquired the response so rapidly that there was little opportunity to detect any possible drug effects. Consequently, a somewhat lower nominal shock intensity (.5 ma) was employed in the study reported.

Male albino rats were obtained from the Charles River Breeding Laboratory and from 70 days of age

were treated daily with intraperitoneal injections of either yeast RNA (160 mg/kg in a 100 mg/ml solution) or equal volumes of physiological saline. All behavioral observations were begun after at least 30 days of injections. Five RNA and five saline, control Ss were given 10 training trials each day for four days. In addition, the buzzer was presented alone without shock on six test trials interspersed among the last 30 trials.

All five Ss in the RNA group made the pole-climbing response on every conditioning or test trial after trial 4. In comparison, none of the control Ss made the response on a single trial. This finding confirms the observation of Cook et al that yeast RNA injections may facilitate the acquisition of the pole-climbing escape response. It does so, however, without necessarily implicating any improvement in the rats' learning or memory processes.

The control Ss never made the desired response, hence they never experienced the cessation of shock consequent upon this response. Each of the RNA injected Ss, on the other hand, did make a pole-climbing response during their first several trials and subsequently profited from the experience by responding more consistently and more quickly on later trials. In the present experiment it is clear that RNA injections increased the original likelihood of the to-be-rewarded response. If RNA had a similar effect in the Cook et al study, in which all Ss eventually learned, the differential acquisition rates which were observed would be most parsimoniously attributed to the interaction of similar learning and memory capacities with the different experiences, rather than appealing to different learning or memory capacities as well.

Experiment II

Two questions must apparently be considered concerning the action of yeast RNA: Why does it increase the original likelihood of pole-climbing in response to shock, and, does it, beyond this effect, also influence the learning or memory processes in a direct way?

A minimal expectation, granting the latter possibility, would be that yeast RNA treatment would benefit the acquisition of a variety of different responses involving a variety of motivation-reward conditions. A second experiment suggests that however general the effects of yeast RNA may be, they do not appear to extend to the acquisition of food-rewarded discrimination behavior.

Fourteen RNA and 14 saline-control rats were injected according to the regime described in Experiment I. They were also placed on a limited feeding schedule

adjusted to maintain their weights between 70 and 80 percent of the mean concurrent weight of saline Ss on an ad lib diet. The two groups were then trained on a food-rewarded discrimination task.

The apparatus was a Y-maze, the dimensions of which have been described elsewhere (Wagner & Miller, 1962), consisting of a grey stem, and one black and one white arm. On each trial S was placed in the stem of the maze and rewarded with six .045 gm pellets if it entered an arm of one brightness and nonrewarded if it entered the alternate arm. Guillotine doors at the choice point were used to prevent retracing once an arm was entered or to block entrance to one arm on forced trials. Half of the Ss in each group were trained to go to the black arm and half to the white. For any S the two arms were interchanged so that each brightness was located equally as often on the left as on the right.

After habituation to the maze, the groups received 11 daily training sessions of eight trials each, patterned after a procedure employed by Spence, Goodrich, & Ross (1959). In each block of four trials the first trial allowed a choice between the two arms, while on each of the next three one of the two arms was blocked so as to equate the total number of exposures to the two brightnesses for each animal.

The major data were the preference behaviors on the two choice trials in each session, but running speeds were also measured on the forced trials to the two discriminanda. Figure 1 presents the mean percentage choice of the rewarded arm for the two groups on successive training days. As may be seen, there was no advantage for the RNA group in the acquisition of this

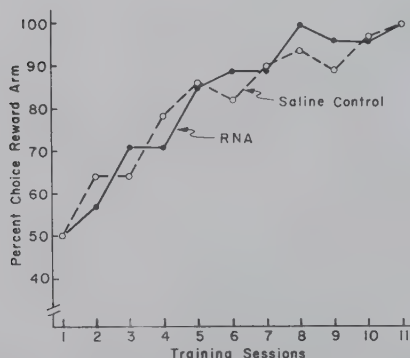


Fig. 1. Percent choice of reward arm in a brightness discrimination for groups of rats receiving daily injections of yeast RNA or physiological saline.

discrimination. The only notable difference in the behavior of the two groups in this experiment was a tendency for the running speeds of the RNA group to be somewhat faster to both the rewarded and nonrewarded discriminanda than those of the saline group, but this difference was not statistically reliable, $F = 2.64$, $df = 1/26$, $p > .10$.

Discussion

From these studies it would appear that although yeast RNA may influence rats' performances in some learning situations, it is doubtful that it does so through any direct effect upon the learning or memory process.

Since RNA was found to increase the original likelihood of responding in a shock situation but not to influence choice behavior in a food reward task, it is possible that it works to sensitize S to shock. In a companion experiment, however, in which the threshold value of shock was determined for producing movement in a stabilimeter, no difference was observed between the means of 18 RNA- and 14 saline-injected Ss.

Another interpretation, consistent, not only with the results of Experiment I, but also with the tendency for the RNA Ss in Experiment II to run somewhat faster than their controls, is that RNA increases general activity level. Again, however, an assessment of this possibility in an activity wheel produced no difference between the means of 18 RNA- and 18 saline-injected Ss.

In summary, the effect of yeast RNA as originally reported by Cook et al, seems likely to result from an increased untrained likelihood of pole-climbing in response to shock, but the basis of this increased likelihood remains obscure.

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Notes

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Visual cliff behavior of mice as a function of genetic differences in eye characteristics¹

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The effects of type of breeding on visual cliff avoidance is evaluated using three groups of mice with different genetically determined eye characteristics—pigmented (P), non-pigmented (NP) and rod-deficient (RD)—tested on 2 occasions. The results show significant group differences on latency and descents. P and NP groups show high degree of cliff avoidance and NP significantly less descents than P. Strain differences were evident on latency and total descents for RD and on bolus count for NP. Latency decreased significantly from first to second test. Inter- and intraspecies differences are emphasized and genetic analysis of determinants of cliff avoidance suggested.

Cliff-avoidance behavior is known to be a widespread response exhibited by many different organisms (Gibson & Walk, 1960; Routtenberg & Glickman, 1964a, 1964b). Also intraspecies differences have been established (Routtenberg & Glickman, 1964a). Yet as the latter authors point out (1964b): "It cannot be stated with certainty, however, whether a type of breeding process has produced animals with specialized sensitivity to height."

Perhaps more is known of the genetic background of the mouse than of any other animal suitable for visual cliff experiments. Since many inbred strains have been maintained for over 20 generations by brother-sister matings, the mouse is particularly well suited for evaluating the effects of selective breeding. This study examines cliff avoidance on two occasions of strains differing in genetically determined eye characteristics (pigmented, non-pigmented and rod-deficient eyes).

Method

Three groups of Ss were used: mice with pigmented eye (P), non-pigmented eye (NP) and rod-deficient eye (RD). The P group consisted of one hybrid and two inbred strains (C57BL/6J, LP/J, and B6D2F₁) with normal retina and pigmented eyes. The parent strains of B6D2F₁ hybrid are C57BL/6Jq and DBA/2Jq.³ The NP group consisted of three inbred strains (129/J, BALB/CJ, and RF/J) with normal retina and non-pigmented eyes. The RD group consisted of three inbred strains (SJL/J, C3H/HeJ, and SWR/J) with hereditary retinal degeneration of the rod layer. Six Ss of each strain were included, giving a total of 18 Ss per group. All Ss were male, naive, and 40-49 days of age at time of testing, except Ss of the LP/J strain, which were 42-55 days old. In home cages the Ss were on ad libitum food and water.

The basic design of the visual cliff followed that described by Routtenberg & Glickman (1964). It con-

sisted of a wooden frame 16.5 in. wide, 21.5 in. long and 31 in. in depth, into which a piece of "Plexiglas" 16.5 in. x 20 in. had been placed, 24 in. above the floor in a horizontal position. A red, pink, and white checkerboard pattern on oilcloth of 7/16 in. squares (alternate rows white and pink squares and red and pink squares) was placed directly under one half of the glass (shallow side) and on the floor under the other half (deep side). The centerboard, 16.5 in. x 3.5 in. x 1.5 in. covered with the same material, was placed across the center of the glass, dividing the surface in half. The "Plexiglas" platform and centerboard were illuminated by a floodlight directed downward and along the centerboard. Another floodlight was directed across the floor of the deep side. The mice were contained by walls of cloth tacked onto the frame.

Each S was placed on the centerboard (facing away from E) and observed for a 5-min. period. After the testing of each S, the centerboard and glass were cleaned with a damp cloth. The following measures were recorded: side and latency of first descent, total time on shallow and deep, total number of descents to shallow and deep, and count of boluses. The E observed from a position in line with the centerboard. The procedure was carried out twice for every S, with a two day interval between test and retest.

(An apparatus control was run to determine any possible differences in the two sides other than the cliff effect. With the pattern directly beneath the glass on both sides (shallow position), a group of 84 animals, independent of the Ss described above and composed of six strains, was tested. Of the 65 Ss descending from the centerboard, 35 went left and 30 right.)

Results

The main analyses show that groups differ significantly on several measures, and suggest differential reactions attributable to strain differences.

The number of Ss in each group descending in the 5-min. session were 16, 8, and 11 for P, NP, and RD respectively ($\chi^2=7.96$, $df=2$, $p<.02$). The NP mice descended significantly less than the P mice ($\chi^2=8.00$, $df=1$, $p<.01$). Initial choice was clearly for the shallow side: none of the P or NP group descended to the deep side compared with four deep choices for the RD group ($\chi^2=9.87$, $df=2$, $p<.01$). Even during the full session only one S in each of the P and NP groups descended to the deep side compared with 9 of the RD group ($\chi^2=18.98$, $df=2$, $p<.001$). A one-way analysis of variance yielded significant differences for latency (5 min. max.; $F=9.073$, $df=2/51$, $p<.001$) and total number

of descents ($F=5.287$, $df=2/51$, $p<.01$). The difference between the mean time spent on the shallow versus the deep side for the RD group—the only group to descend consistently to both sides—was not significant (M shallow = 107.40 sec., M deep = 119.67 sec.)

A one-way analysis of variance was applied to within group differences for strains. The F -ratio for latency of descent was significant beyond the .001 level for the RD group ($F=18.15$, $df=2/15$), the SJL showing shorter latency than the SWR and C3H. The only significant difference in total descents was again the RD group ($F=56.618$, $df=2/15$, $p<.001$) and attributable to the SJL strain with the highest number of descents. For bolus counts the analysis was significant for the NP group ($F=5.482$, $df=2/15$, $p<.05$) with the BALB strain showing least counts.

On the second test the differences among groups comparing descenders and non-descenders was not significant (Descenders: $P=16$, $NP=10$, $RD=12$). However, on the initial choice the strong avoidance of the deep side of the P and NP groups was still evident, with no deep choices compared to 5 choices for the RD group ($\chi^2=12.48$, $df=2$, $p<.01$). During the course of the second test the proportions of Ss going to the deep side were 5 of 16, 2 of 10, and 12 of 12 for the P, NP, and RD groups respectively ($\chi^2=17.85$, $df=2$, $p<.001$).

Latency was the only measure to show a significant shift from the first to the second test. Application of a two-way analysis of variance with one-way correlation yielded significant F -ratios for the main effects of session, decrease in latency ($F=8.307$, $df=1/51$, $p<.01$), and groups ($F=7.642$, $df=2/51$, $p<.01$). The interaction of latency and groups was not significant.

Discussion

In general mice of various strains with normal retinas and pigmented and non-pigmented eyes show visual cliff avoidance similar to other organisms and stable responses, except latency of initial descent, over two test sessions.

One possible reason for the lower number of descents in the non-pigmented eye group is that a non-pigmented eye provides less discriminatory ability than a pigmented one (Lashley, 1930). However, this does not appear to be a sufficient explanation since those Ss to descend clearly manifested cliff avoidance. Taking bolus counts as a measure of emotionality the NP group did not differ significantly from the P and RD groups. A remaining possibility is that the mice in the NP group were simply slow to respond. Some support for this interpretation may be found in the data for the appar-

atus control group: only 7 of 12 of strain 129/J descended even when both sides were in the shallow position.

Evidence of a defect in visual discriminatory ability in strains SJL/J, SWR/J and C3H/HeJ is seen in the lack of significant differences in responses to the shallow and deep sides. (Incidentally, this is additional evidence for the lack of difference between the two sides, apart from the visual cliff.) The results are consistent with the finding of Wimer & Weller (1964) of an inability of these strains to learn a brightness discrimination. However, in the light of the differences between the RD strains, it seems that accommodation to visual deficit is different for different strains.

In contrast with other studies (Routtenberg & Glickman, 1964a, 1964b) the mice in this study show greater cliff avoidance than other rodents including spiny mice, and no difference between pigmented and non-pigmented eye. Further tests showed this discrepancy not to be a function of size of square—a difference between the two studies and the present one. (The 16 Ss of the P group which descended were divided into two groups, matched for total descents and strain, and tested without a centerboard. Time on deep and shallow was recorded, using the original square for one group and a 2-1/4 in. square for the other, and mean percentages of time on deep were 28.00 and 21.00 respectively, a non-significant difference.) Apparently, the differences are inter- and intraspecies differences.

The mouse appears to be well suited for further genetic and behavioral analysis of visual cliff avoidance.

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Stimulus control of the prey attack response in naive garter snakes¹

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Newborn garter snakes without prior feeding experience were found to selectively respond with attack behavior to water extracts of organisms normally eaten in captivity and not to respond to extracts of other organisms and controls. Differences were noted in the frequency and latency of responding to the effective stimuli. This response to chemical stimulation did not easily habituate. Visual stimuli may cause the S to orient toward and "explore" a potential food object, particularly if moving; but it is concluded that the basic somatic movements involved in the attack of prey are present at birth and that this behavior can only be elicited by certain chemical stimuli in naive Ss.

Chemical stimulation is generally considered as being of great importance in the feeding and social behavior of many snakes (Noble, 1937), but no work has been done on the responses of newborn young to isolated sensory cues. When a litter of newborn garter snakes became available it was decided to investigate the stimuli necessary to elicit the prey attack response before learning could be a factor. This response has been shown to be under control of the vomeronasal portion of the olfactory system which is unusually well developed in snakes (Wilde, 1938).

Subjects

The Ss were 24 garter snakes produced in a litter by a gravid female *Thamnophis s. sirtalis* collected near Valparaiso, Indiana.² The day following their birth, the Ss were transferred to individual glass 6 quart tanks measuring 23 x 14 x 17 cm. Each S was visually isolated from its neighbors by cardboard partitions. The aquaria contained 2 cm of sand which was sprinkled with water twice daily. The Ss were allowed one day to adapt to the tanks before the experiments commenced. The temperature ranged between 26–32°C.

Method and Results

The first experiment was designed to determine whether the ingestively naive S will respond to a chemical stimulus alone with the characteristic prey attack response or whether an association or reinforcement contingency is involved.

Extracts of 4 animals were used: redworms (*Eisenia foetida*), mealworms (*Tenebrio molitor* larvae), minnows (*Notropis atherinoides acutus*), and horsemeat. Worms and fish are readily taken in captivity by these garter snakes but insects and meat are not. The method of extraction was modified from Wilde (1938). Three grams of each item were washed in distilled water (except for the ground meat), dried on absorbent paper, and dropped into 20 cc of distilled water at 60°C. The

instantly killed animals were stirred slowly for 1 min. and then removed. The solution was filtered through Whatman No. 54 filter paper and the filtrate was clear and colorless and refrigerated in sealed glass vials until use.

The extracts were presented to the Ss with commercial cotton swabs on 15 cm wooden sticks. The tip of the swab was dipped in the extract and the excess removed with a quick shake. The swab was slowly moved toward the head of the S and kept about 1 cm away. If no response was made within 0.30 min. the swab was moved closer to the S until it lightly touched its lips. The S was given a total of 1 min. to respond. If it did respond the elapsed time was recorded to 0.01 min. Ten min. before and after the test stimulus, a distilled water control swab was presented in an identical fashion. Twenty Ss were run on the 4 stimuli. Four variations of the order of presentation were used with 5 Ss per sequence; each S was tested only once with each stimulus. The first two stimuli were presented on the third day after birth and the second two the following day at the same time.

No response except tongue flicking was elicited by the control swab or by the horsemeat and mealworm extracts. All 20 of the Ss responded with the attack response to the redworm extract and 13 responded to the minnow extract (this difference is significant: $\chi^2 = 6.23$, $df = 1$, $p < .02$). There was also a difference in the mean latency; that to redworm extract averaged 0.202 min. and that to minnow averaged 0.249 min. No significant order effects were apparent in the data.

The response to an effective stimulus was very clear-cut. The S increased its rate of tongue flicking and then lunged forward at the swab with its jaws open wide at about a 45° angle. To prevent the snake from entangling his teeth in the cotton, the swab was removed at the moment of the strike. This response was identical with that seen toward live redworms and small fish (guppies, *Lebistes reticulatus*) given to two young not involved in the above tests but previously unfed. They refused the horsemeat and live mealworms, but would attack and eat horsemeat dipped in the worm extract.

The second experiment dealt with the stability of the response to chemical stimulation. Two Ss neither previously fed nor involved in the chemical tests above, were presented with the worm extract at 5 min. intervals for 20 trials. Since the specificity of the response had already been demonstrated the control swab was presented only before the 1st test, after the 10th, and after the last trial. The results are shown in graph

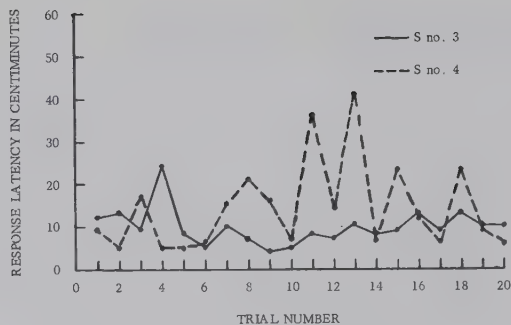


Fig. 1. Latency of prey attack response to swabs dipped in red-worm extract and presented at 5 min. intervals.

form in Fig. 1. Both Ss responded on every trial and there was no gradual lengthening of the response latency. It should be noted that S No. 4 displayed more variation than S No. 3 and this appeared due to its greater "nervousness" or initial flight as the E began to introduce the swab.

The 20 Ss used in the chemical tests were utilized in experiments on visual stimuli performed on the 5th day after birth. Ten Ss were presented with a 5 dram glass, plastic stoppered vial containing water and 3 guppies; the control vial contained the same amount of water. Five Ss were presented with a vial containing 3 redworms and 5 with a vial containing 5 mealworms. The control vial was placed lengthwise in the sand in front of the tank and after 1 min. was removed. Ten min. later the test vial was introduced which was also removed after 1 min. Any behavior directed toward the vial was recorded as well as the latency of the response. The 10 Ss not presented with live guppies were tested on dead guppies in water the following day.

The first thing to be noted about the results is that in no case did the visual stimulus of living prey elicit the attack response. However, a definite pattern of behavior was often noted that differed from the controls. This behavior was an orientation towards the vial, increased tongue flicking, and approach. Four of the 5 Ss responded to the redworms but with a reaction so weak that no meaningful latency measure could be recorded. The same number responded to the faster moving mealworms but with a more marked response and a mean latency of 0.24 min. Six of the Ss reacted to the quickly swimming fish with a mean latency of 0.06 min. There

was no overlap in the latencies for the three stimuli. The strength of this visual response seemed strongly correlated with the amount of movement of the animals in the vials, though, of course, the three species also differed in their external morphology and mode of locomotion. That the critical factor was movement seems substantiated in that the response was directed to that part of the vial where there was movement, and the 10 Ss given dead guppies showed no response. This visually released behavior soon habituated and reintroduction of the vial shortly afterwards led to either little or no response.

Discussion

These preliminary experiments clearly indicate the importance of chemical stimulation in the feeding behavior of newborn garter snakes. Being presented on cotton swabs, there was, of course, a visual factor which undoubtedly aided in the directing of the response, though not in its elicitation. It would appear that we are here dealing with an innate behavior pattern critically dependent upon specific chemical stimuli. Environmental events later in ontogeny may, of course, influence subsequent behavior to chemical and visual stimuli.

It is possible that imprinting may play a role in determining which chemical stimuli are most effective in the adult snake. Previous work has shown that in turtles food preferences can be differentially modified due to early experience (Burghardt & Hess, 1966). It seems most likely that if food imprinting is present in snakes the imprinting is actually to the specific chemicals involved. The differences in the parameters of the response to the worm and fish extracts suggest that a different active substance(s) is critical in each case.

In the light of these results it appears possible that snakes could prove very useful organisms in the study of chemical sensory mechanisms due to their dependence upon them and the stereotypy of the responses.

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Notes

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2. Thanks are due Erich Klinghammer and Gitta who found the snake.

Temperature gradients in the rabbit eye

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Temperature measurements of the eyes of adult albino rabbits showed consistent gradients from the anterior surface of the retina to the outer surface of the cornea. Average difference between temperature at the retina and at the outer surface of the cornea was 5.01°C . Between rectal temperature and temperature at the outer surface of the cornea, average difference was 5.84°C . Temperature readings at points on the surfaces of ocular structures showed a consistent tendency to be highest in the lower nasal quadrant and lowest in the upper distal quadrant.

Duke Elder (1940) attributed circulation of intra-ocular fluid to three influences: primary metabolic interchange, pressure circulation, and thermal circulation (a purely physical phenomenon) within the anterior chamber caused by difference in temperature between the air-cooled cornea and the vascularized iris. He refers to his own research in 1927 in which a difference of 3°C to 5°C was found between the cornea and the iris of rabbit eyes, and to the research with rabbits of v. Michel in 1886 and Nelson in 1927. v. Michel reported rectal temperature as 38.5°C , temperature in the middle of the anterior chamber as 31.9°C , and in the lens as 36.1°C . Nelson found average differences of 1.5°C and 3.5°C between rectal temperature and temperature of the aqueous humor of the closed and open eye respectively. In the present study, a series of temperature readings was made from the anterior surface of the retina to the outer surface of the cornea in order to establish a more comprehensive map of temperature gradients in the eye.

Method

Seven adult albino rabbits, anesthetized with either phenobarbital or eurthane, were used. Temperature measurements were made with Veco thermistors, types 55A1, 52A1, and 47A1, with a GR bridge to measure resistance changes. Calibration points of the thermistors were established with an ice bath (0°C) and the melting point of Benzophenone (48.5°C).

Eyelids were permanently reflected and the eye penetrated in the top distal quadrant by a hypodermic needle (outside diameter, .05 in) containing a thermistor. The needle was then withdrawn and temperature measurements made at selected loci. In three animals, both eyes were used, consecutively. In the other four animals, measurements were taken in only one eye, two being left and two right eyes.

Temperature readings were taken at the anterior surface of the retina, in the vitreous body, and at the posterior surface of the lens, posterior surface of the iris, and posterior and anterior surfaces of the cornea. In the vitreous, thermistors were located in the center of the

eye approximately half way between the anterior surface of the retina and posterior surface of the lens.

At the beginning and end of each series of temperature measurements from an eye, rectal temperatures were recorded. The mean of these two readings was taken as rectal temperature for a given animal.

Results and Discussion

Figure 1 shows average temperatures of 10 rabbit eyes at various loci in the vertical and horizontal planes of the eye. Temperature rises consistently from the outer surface of the cornea to the anterior surface of the retina. When average readings at five points on ret-

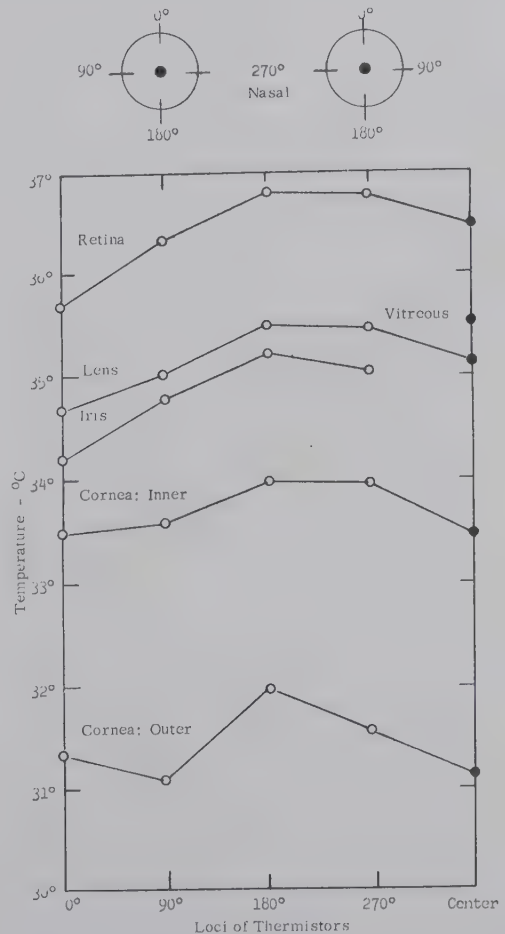


Fig. 1. Mean temperatures of 10 rabbit eyes at various loci.

ina, lens and inner and outer surfaces of the cornea were averaged, they yielded values of 36.39°C , 35.13°C , 33.67°C , and 31.38°C for these structures respectively. The average of temperatures at four points on the iris was 34.81°C , and the average temperature in the vitreous body was 35.46°C .

All measures were relatively consistent from eye to eye. The largest standard deviation was 0.73°C for readings at a single locus in the vitreous body. Other standard deviations were 0.39°C for readings at the retina (5 loci) and iris (4 loci), and 0.30°C , 0.21°C , and 0.11°C respectively for readings at the lens and inner and outer surfaces of the cornea (5 loci each).

Within the vertical planes there is a slight but consistent tendency for temperatures to be highest in the lower nasal quadrant and lowest in the upper distal quadrant. The average of readings taken at locus 180°

was 34.67°C ; at locus 270° , 34.54°C ; at locus 90° , 34.14°C ; and at locus 0° , 33.85°C .

Average rectal temperature was 37.22°C , with a standard deviation of 0.72°C .

The significance of the data is that they show consistent gradients in temperature in both the anterior and posterior chambers of the eye and at points in vertical planes within these chambers. They are not necessarily representative of normal temperatures in the rabbit eye because (1) animals were anesthetized, (2) eyelids were reflected, thereby exposing atypical cooling surfaces, and (3) the effects of pressure and loss of fluid caused by penetration of the eye are unknown.

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Better discriminated bar-press avoidance at short intertrial intervals

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Four groups of rats received discriminated avoidance training in Skinner boxes at intertrial intervals (ITIs) of 0.2, 1, 5, or 30 sec. As ITI decreased avoidances and bar presses per min. increased and differences among groups persisted when ITI was then increased to 30 sec. for all groups. The better avoidance at short ITIs was attributed to response perseveration after shock and the results were related to those obtained without an exteroceptive warning stimulus (Leaf, 1965) and to those with discontinuous shock (D'Amato, Keller, & Di-Cara; 1964; Hurwitz, 1964).

Mention has often been made of difficulties in establishing discriminated avoidance responses in Skinner boxes (D'Amato & Schiff, 1964; Chapman & Bolles, 1964; Meyer, Cho, & Wesemann, 1960; Pearl & Edwards, 1962). That the number of avoidance responses can be increased by decreasing intertrial interval (ITI) seemed to merit more research (Pearl, 1963). The present study investigated whether the improvement in avoidance continued when ITI was further decreased and whether any initial improvement persisted when ITI was then increased.

Method

Subjects

Ss were 32 Sprague-Dawley male rats weighing from 170 to 210 gm.

Apparatus and Procedure

The Skinner box and the shock generator were previously described (Pearl & Edwards, 1962). The shock generator was set at the 3 ma calibration and the CS was an increase in white noise level from 61 to 80 db. The CS was programmed to act alone for 20 sec. and then with the UCS for 5 sec. A bar press ended the CS and prevented delivery of the UCS or ended both the CS and UCS. Holding the bar down had no effect on experimental operations: The bar had to be released and pressed again to have any effect. There were 200 trials of training on each of five consecutive days. On days 1-4 ITI was different for four groups of eight Ss each: 0.2, 1, 5, 30 sec. as measured from the end of a CS to onset of the next CS. On Day 5 ITI was 30 sec. for all groups.

Included are means for percentage of avoidance responses, latencies for trials on which there was an avoidance response (avoidance latency), and bar presses per min. Bar presses per min. rather than total presses are presented because the former showed a relationship to ITI more clearly than the latter. Records of escape responses and of escape latencies are not

included because they were unrelated to ITI. Differences in performance among groups on each day were evaluated with the Kruskal-Wallis analysis of variance.

Results

The left hand section of Fig. 1 shows means for percentage of avoidance responses; the middle section, avoidance latencies; the right hand section, presses per min. Inspection of the curves suggests that as ITI decreased avoidances increased, avoidance latencies decreased, and presses per min. increased. Avoidances on Days 1-4 increased significantly as ITI decreased ($ps < .05$ on each day) and, except perhaps for the 0.2 sec. ITI group, the same relationship held on Day 5 when ITI was 30 sec. for all groups ($p < .01$). Although the relationship of avoidance latencies to ITI was statistically equivocal, avoidance latencies tended to decrease as ITI decreased ($p < .05$ on Day 3; $ps > .10$ on other days). The differences among groups in bar presses were significant on each day ($ps < .01$). On Days 1-4 the differences in presses can be attributed to the artifact that most presses were being made to shock or shortly thereafter and that the duration of the training session for short ITI groups was less than those for long ITI groups. However, at least some effects of prior ITI training persisted on Day 5 when ITI was the same for all groups.

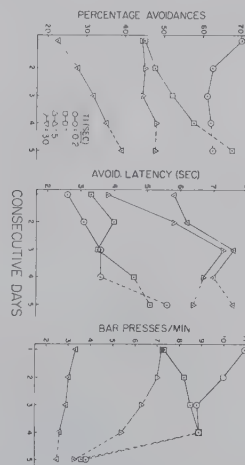


Fig. 1. Percentage of avoidance responses, avoidance latencies, and bar presses per min. as a function of ITI. (On Days 1-4 ITI was different for each of four groups; on Day 5 it was the same for all groups.)

Discussion

The major finding of this study was that avoidance continued to improve as ITI was decreased to approximately 1 sec. and that the improvement persisted when ITI was then increased. The improvement may be related to the fact that perseveration of responding after shock is more likely to result in avoidance responses when the ITI is short than when it is long and that this pattern of responding, once established, may persist when ITI is then increased. Agreeing with the results of the present study are those of a previous study dealing with ITI interval and discriminated avoidance (Pearl, 1963) and those of a study without an exteroceptive warning stimulus (Leaf, 1965).

Interestingly, the use of short ITIs may in part account for the better avoidance with discontinuous shock as opposed to continuous shock (D'Amato et al., 1964; Hurwitz, 1964). The continuous shock group in these studies received training at long ITIs in a manner similar to the procedure of the present study. But the discontinuous shock groups were trained with brief periodic shocks given every few sec. and the CS

acted till the rats responded. So during a given trial of training there was a brief interval between successive shocks and no interval between shocks and the continually acting CS.

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Erratum

Woodburne, L. S. Visual acuity of "Saimiri sciureus." *Psychon. Sci.*, 1965, 3, 307-308.

Woodburne, L. S. Geometrical shape discrimination by "Saimiri sciureus." *Psychon. Sci.*, 1965, 3, 309.—Both articles should have contained an acknowledgment that the research was supported by National Institutes of Health Grant NB-04521-02.

Visual discrimination in deermice¹

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Five species of deermice (*Peromyscus*) were tested for a light-on, light-off discrimination with water reinforcement. All species acquired the discrimination similarly, but the number of bar pressing responses during the S^D differed among the species. Species-specific reactions to the water deprivation and the test situation could account for the S^D response rate differences.

Comparisons of behavior among closely related species can suggest the nature of the selective forces responsible for the evolution of species-specific behavior patterns. Since species-specific behavior is largely a product of natural selection operating in the native environment of that species, small differences in behavior related to a particular environment may indicate the visual mechanism. Differences in age of eyelid-opening and adult lens size (adjusted for body weight) among several species of the rodent genus *Peromyscus*. (deermice) King, 1965), suggest that some visual process has been differentially selected in the environment characteristic of each species. The purpose of this investigation was to determine whether this visual process was related to adaptation to a visual cue. The readiness with which a species learned a simple light-off, light-on discrimination could indicate attentiveness to the visual cues. The operant procedures described by Herrick, Myers, & Korotkin (1959) and Pierrel & Sherman (1962) were used for this purpose.

Method
Ten Ss from each of five species and subspecies were tested: *Peromyscus maniculatus gracilis*, *P. m. bairdii*, *P. leucopus*, *P. eremicus*, *P. floridanus*. The laboratory history of these stocks is described in King (1965) and King & Weisman (1964). Their geographic distribution, phylogenetic relationships, and habitats are given in Hall & Kelson (1959). Two identical plastic boxes 4.5 in. by 5 in. by 6 in. were used as test chambers. Solenoid operated water dispensers (Polidora & Meyer, 1961) delivered 0.04 ml. of water. The S^D was a disc of projected light from an Industrial Electronic Engineers, Inc. display cell. The test chambers were in a sound deadened, temperature controlled room at 70°F. Programmers and relay circuits in another room controlled the length of S^D and S^A periods and independently presented a VI 1 min. schedule of reinforcement during S^D periods.

Ss had food available ad lib in home cage, but water was available only in the test chambers. Ss were shaped with continuous reinforcement from 2-4 days and trained on the VI 1 min. schedule in the presence of S^D for 1 hr. each day over the next 3-5 days. During discrimination, all Ss had water reinforcement on the VI 1 min. schedule during S^D periods (light-on) and no

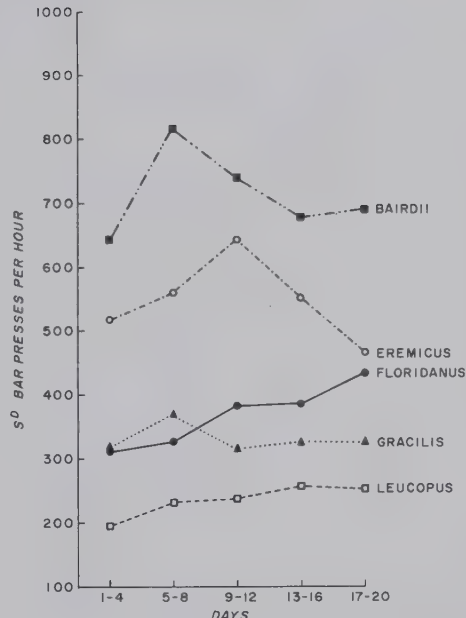


Fig. 1

reinforcement during S^A periods (light-off). S^A periods of 2, 4, and 6 min. were alternated with S^D periods of 1, 2, and 3 min. for a 1 hr. test period providing 40 min. S^A and 20 min. S^D . Each S was tested 1 hr. per day for 20 days. Extraneous stimuli were controlled by disconnecting S^D lights for an additional test day of an hour. Without the light, Ss bar pressed at a constant rate throughout the test hour.

Results

Figure 1 shows the mean number of bar presses during S^D periods averaged over four day blocks. The rate of pressing remained more or less constant over sessions ($F=1.502$, $df=4/180$), but this "constant" rate was different for each species ($F=4.923$, $df=4/45$, $p<.01$). Individual comparison between species (Duncan's test, $p<.05$) showed that *P. m. bairdii* and *P. eremicus* pressed more frequently during S^D periods than *P. leucopus*, *P. floridanus*, *P. m. gracilis*.

The results of discrimination training on the discrimination ratio (S^A responses/ $2S^D$ responses) are shown in Fig. 2. The discrimination ratio decreased over days for all species ($F=69.75$, $df=4/180$, $p<.001$). The species all appear to have learned the discrimination at the same rate since neither the main effect for species ($F=1.290$, $df=4/45$) nor the interaction with sessions ($F<1.0$, $df=16/180$) was significant.

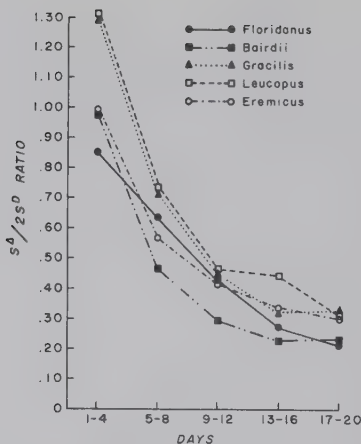


Fig. 2

Discussion

The five species and subspecies tested in this experiment are morphologically similar except for the divergence in relative eye size indicated by fresh lens weight, which ranged from 0.87 mg lens wt./gram body wt. in *P. eremicus* to 1.25 mg/g in *P. floridanus* (King, 1965). Despite this divergence of eye size, the light served as an adequate cue to all species tested. Furthermore, all species were equally capable of learning the discrimination. Apparently the phylogenetic and ecologic divergence of these species has not resulted in differences in their capacity to make a simple visual discrimination. The divergence in eye size requires an alternative explanation which is not readily apparent.

The primary difference in this study is in the number of bar presses during S^D . Since none of the species changed bar-pressing rates significantly over the 20 sessions, the different rates suggest species-specific behavior in the response required or in the motivational levels. All species pressed the bar easily, but direct observations of their pressing behavior revealed interesting differences. *P. eremicus* was exceedingly active and leapt about the chamber, frequently striking the bar in the process of leaping. Some individuals of

P. m. bairdii grasped the bar in their teeth and shook it vigorously. Both behaviors could account for the high rates in these two species. *P. floridanus* often depressed the bar, but not far enough to make it operate. *P. leucopus* pressed the bar adequately, but they tended to sit motionlessly in a corner of the chamber.

Motivational properties of the water may vary in accordance with the availability of water in the habitats of the mice. *P. eremicus* is an inhabitant of the desert; *P. m. bairdii* inhabits grasslands; and *P. leucopus* and *P. m. gracilis* are from mesic forest habitats. Although *P. floridanus* inhabits areas of heavy rainfall, Fertig & Layne (1963) found their habitat to be xeric. Water consumption per gram body weight is not conspicuously different among these species (Lindeborg, 1952). While motivation for water has yet to be systematically examined, their response to water deprivation may be more critical. For example, *P. leucopus* may have been subdued by water deprivation and the novelty of the testing situation. In contrast, the same situation may have excited *P. eremicus* and *P. m. bairdii* to hyperactivity and frequent accidental bar presses.

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Notes

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Discrimination-reversal skills of primates: The reversal/acquisition ratio as a function of phyletic standing^{1, 2}

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The ratio of reversal performance to acquisition performance in discrimination reversal learning differentiated primate groups and varied with acquisition proficiency.

There is general agreement that the capacity to execute efficient reversals of previously mastered discriminations has increased with the evolution of animal life and that in some manner this capacity contributes to the extraordinary concept formation skills characteristic of primates (Harlow, 1958). That discrimination-reversal skills might be particularly sensitive to the species variable (Harlow & Hicks, 1957), basically involved in those mediational processes which both anticipate and involve language (Kendler & Kendler, 1964), and a contributor to the varied effects of overtraining upon performances which apparently interact with both the species and task variables (Warren, 1962; Reese, 1963; Sperling, 1965) makes the understanding of reversal processes particularly important.

Method

Data of certain discrimination reversal (DR) experiments, all conducted locally, were analyzed to compare acquisition (A) and reversal (R) performances for a group of squirrel monkeys with another group comprised of apes and macaques.

All Ss had served previously in learning-set studies which entailed approximately 2,000 to 3,000 trials of either 6-trial and/or criterional object-quality discrimination problems. The DR data for 7 squirrel monkey Ss (*Saimiri sciureus*) were from the 50 problems of Phase III of the Rumbaugh & Ensminger (1964) study; DR data for a group of 16 ape (6 *Pan*, 6 *Gorilla*, 3 *Pongo*, 1 *Hylobates*) and 5 macaque monkey Ss were from the Rumbaugh & McCormack study program (1965, also Rumbaugh & Rice, 1962). In the latter study measures were from the last 11 problems of DR training, those problems being the ones within which Ss achieved an interproblem criterion (10 correct trial 2, reversal). Of 23 Ss given this training, the 21 that met that criterion were selected for purposes of comparisons drawn in this paper.

All measures were taken in WGTA test situations and from experimental phases in which, on a random basis among problems, either 7, 9, or 11 acquisition trials preceded 8 reversal trials. All Ss were food deprived and received a variety of rewards from foodwells bared by a pushing response directed toward the object chosen on a given trial. Noncorrection training methods were used in all instances.

Results and Discussion

Each squirrel monkey S was matched either with an ape or macaque S on the basis of performance on A trials. The 6 ape and 1 macaque Ss selected by this matching procedure held quite constant from A to R (Table 1), but their squirrel monkey counterparts dropped from A to R an average of 8.50% ($t=4.34$, $df=12$, $p<.01$).

There is good reason to believe that these particular squirrel monkeys were superior in their DR skills, for

Table 1. The Acquisition and Reversal Performances of Seven Squirrel Monkeys and Their Ape or Macaque Members Matched for Acquisition Level

Acquisition (trial 1 _A excluded)			Reversal (trial 1 _R excluded)	
Squirrel Ss	Matched Ss	(years age)	Squirrel Ss	Matched Ss
88.75%+	89.00 C-3*	2.8	79.72	91.40
88.23	88.40 C-2	3.3	76.57	87.00
84.23	85.20 O-3	4.4	80.29	83.10
82.50	83.70 M-11	17.0	80.57	88.30
82.48	83.70 G-11	6.6	71.43	90.90
82.48	82.60 C-4	3.1	71.43	77.90
81.70	80.20 G-1	2.6	70.86	80.50
$\bar{X} = 84.34\%$	84.69%		75.84%	85.59%

*C = Chimpanzee, G = gorilla, M = macaque, and O = orangutan

they had been selected for use as Ss in the Rumbaugh and Ensminger study by reason of their relatively high-order learning set performance in earlier experiments. Assessment of the DR proficiency of the ape/macaque Ss of Table 1 revealed that as a group they were slightly above average, as $\bar{X}_A = 78.60\%$ and $\bar{X}_R = 83.80\%$ for the entire group ($N=21$) from which they were drawn. For the best 7 Ss of the ape/macaque group, $\bar{X}_A = 91.43\%$ and $\bar{X}_R = 88.37\%$; for the worst 7 Ss of that group, $\bar{X}_A = 73.24\%$ and $\bar{X}_R = 78.27\%$. Whereas the best 7 Ss dropped in percentage correct from A to R and the worst 7 Ss gained from A to R, those 7 Ss selected (Table 1) held quite constant. A split of the original $N=23$ (includes 2 Ss that did not meet the interproblem criterion for DR) at their median A similarly revealed that of the Ss above the median, 9 dropped from A to R and of those below the median 9 gained (median sign test $p<.01$).

As matching on A had not yielded comparable R values, it was considered that possibly matching on R might yield comparable A values. Matching procedures yielded an ape/macaque group with an $R = 77.16\%$, a value which corresponds closely with the squirrel monkeys' R value of 75.84%. The A values associated with the R matched members differed markedly, however, $A = 84.34\%$ for the squirrel monkey Ss and $A = 73.06\%$ for the ape/macaque Ss ($t=3.02$, $df=12$, $p<.05$).

That neither of the matching procedures resulted in two groups with comparable A-R skills carries the implication that the R/A functional relationship varies among primate groups, most probably according to fundamental differences in how they go about learning discrimination problems. Equivalent A levels for differ-

ent primate groups does not imply equivalent R levels, and vice versa. Alternatives, such as the one of transfer suppression (Riopelle, 1953) operating differentially among taxa, will have to be explored (e.g., Warren & Kimball, 1959).

Figure 1 portrays R/A functions, in reference to A levels, as we believe them to be on the basis of the foregoing analyses. In addition to those 7 squirrel monkeys of Table 1, 4 other squirrel monkeys, whose points are below $A = 80\%$, are included. Their training consisted of 1,800 trials of DR training given in accord with the previously described methods, but this was their very first training in a formal training situation, i.e., they had no prior learning set training. Their R/A ratios and A values were calculated for the last 25 problems of that training. Since the other 7 squirrel monkey Ss, superior for their kind, all dropped from A to R, less superior Ss should have lower A levels and lower R/A ratios. But since totally naive Ss should be initially 50% correct on both A and R, the R/A ratio must begin at 1.00.

All members of the ape/macaque pool ($N = 21$) are included in Fig. 1. The solid-line portion of their function is reasonably well buttressed by Ss' values. Note that it drops below $R/A = 1.00$ where A values are high in accord with the finding that ape/macaque Ss above the median A

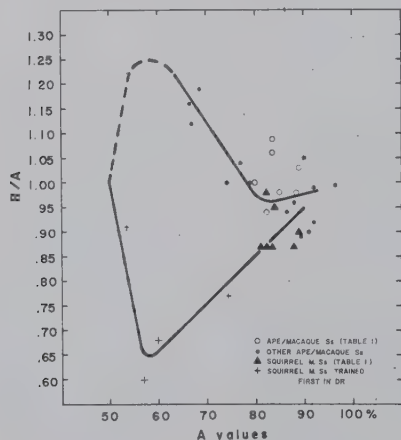


Fig. 1. The R/A ratio values (%+ on reversal/%+ on acquisition) plotted as a function of A values (%+ on acquisition) for groups of Ss as indicated.

dropped from A to R. The broken portion of the proposed summary function is, to date, unsupported by empirical data; its shape was deduced from its known value where $A = 65\%$ and our contention that the factor which will differentiate ape/macaque Ss from squirrel monkey Ss, given that they are naive and introduced to fixed-trial DR training, is that their initial learning will be manifested in R rather than A performances, yielding $R/A > 1.00$ for apes and macaques and $R/A < 1.00$ for squirrel monkeys.

Our analysis of the R/A ratio's functional relationship implies that primate taxa differ not only in capacity to (a) acquire discrimination learning sets and (b) acquire discrimination reversal sets for problems of a given class, but also with respect to the way in which these two kinds of sets develop and function one with another.

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Notes

1. Supported by NSF Grant 1942. Austin H. Riesen's contributions of interest and critical comment are gratefully acknowledged.
2. Subsequent to our formulations and writing of the present paper there has been published a closely related paper of considerable interest: Rajalakshmi, R., & Jeeves, M. A. The relative difficulty of reversal learning (reversal index) as a basis of behavioural comparisons. *Anim. Behav.*, 1965, 8, 203-211.

Stereotactic implantation for small animals: A "wire-bridge" technique¹

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The technique and advantages of a new implantation method is described.

Of the various implantation techniques in use for rats and other animals, that first used by Albino in 1954 (Albino & Spearman, 1957), has the advantage of allowing the placement of a number of electrodes independently of each other within a relatively large area of the skull. Three or more screws are fixed into the skull and dental cement is used to anchor each electrode in place. The jeweller's screws are, however, usually driven through the skull, and the 1 mm or more that protrudes deforms the underlying tissue, soon rusts, enlarges, and effectively prevents the plant from coming away from the skull. It probably also causes both primary and secondary brain damage.

The use of screws in our laboratory has not met with the success claimed for it by others. In many cases, removing a stilette and fitting a micro-injection cannula, or fitting an electrode attachment to an assembly, resulted in its coming away from the skull. The use of small wood screws and of tantalum orthopedic screws met with as little success. This was perhaps due to our wishing to avoid damage consequent upon screws protruding through the skull. What was required was some technique using stainless steel which would not involve brain damage.

After attempting a number of techniques, one was developed which proved so effective that since July 1964 it has been used routinely for all implants, none of which have been lost.

Method

Using a dental drill with thyristor control to allow high torque at low speed, two pairs of holes are drilled, bilaterally (size 2/0 inverted cone drill reduced in diameter on a grindstone), on the dorsal surface of the frontal and parietal bones. The rostral pair are about 2 mm in front of the lambda and the caudal just rostral to the bregma. Each hole is drilled at about 45° to the horizontal plane, outwards, and about 2 mm from the dorso-lateral flexure of the skull. Rocky-Mountain arch wire of .015 in diameter is then cut to a length

one quarter longer than the separation of the holes, bent with two artery forceps, and the ends fitted into the holes. The same procedure is repeated to form the second bridge. Holes are then drilled for the electrodes or cannulae and these are held by flowing dental cement (cold-cure acrylic) around them and the bridges. Many electrodes can be placed by allowing the cement to set for each before placing the next, one bridge being sufficient to hold electrodes during implantation. Since the area between the bridges is relatively large, and since placements can be anywhere in this area as well as on both sides of either bridge, the only limitation on the number and placement of electrodes is due to their physical size or through the type of electrode attachment used. The bridges do not have to be placed transversely but can be angled to accommodate electrodes in a particular area. Their separation can also be varied. If required, the arch wire can be insulated by using one of the solutions mentioned in Scheer (1961).

Advantages.

This technique has the advantage of being firmer than others, but it is, in addition, extremely rapid to perform, the materials used are less expensive and the resultant plant is smaller since the bridge has its highest point at the center and is even here only a couple of millimeters above the skull surface. Perhaps the chief gain is, however, the negligible damage to the brain. Since the arch-wire penetrates at the flexure of the skull where there is a ridge with thicker bone, and where the brain surface is curved laterally, the chance of damaging cortex is slight. Post mortem confirms that there is no damage to cortex. And since stainless steel wire is used, little long-term deterioration can result.

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Note

1. This research is supported, in part, by the South African Council for Scientific and Industrial Research.



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Incidental learning with "omitted" context cues¹

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In a paired-associate learning task, context stimuli were present on study trials and absent on test trials. The context stimuli were then used as stimuli on a transfer task in one of three paradigms: A-B, A-B; A-B, A-Br; A-B, C-D. Performance on the transfer task indicated that associations had been formed between context stimuli and the appropriate responses on the original list.

Several recent studies have investigated the effect of context stimuli on paired-associate learning (e.g. Hill & Wickens, 1962; Saltz, 1963). Saltz (1963) found that colors which surround verbal stimuli on study trials facilitated learning, even when the colors were absent on test trials (C-NC condition). It was suggested that facilitation under this condition is a result of acquired distinctiveness of the verbal stimuli, since the colors are not present to serve as additional cues on the test trials. It is also possible that color facilitates learning in the C-NC condition via mediation, i.e., on the test trials the verbal stimulus leads to covert elicitation of the appropriate color name, providing an additional cue for the response.

Birnbaum (in press) found that during C-NC learning, associations develop between (1) the verbal stimulus and the context stimulus, and, (2) the context stimulus and the appropriate response. These results may be described as instances of incidental learning, since the instructions for original learning (OL) do not prepare S for any subsequent test of information about the context cues (Postman, 1964). Furthermore, the instructions as well as the omission of the context cues on test trials make it clear that S's task is to learn to respond to the verbal stimulus alone. Incidental learning which involves context cues might contribute to the facilitation which was observed in the C-NC condition (via the mediational chain described above).

Results of the prior studies might be restricted to the situation in which color, a salient feature of the compound stimulus, is used as the context cue. The present study investigated the generality of the findings on incidental learning, especially with respect to a different class of context stimuli. New materials were used on both the stimulus and response sides, and the context cues were single letters instead of colors.

Method

Ss learned a list of eight paired-associates to a criterion of one perfect recitation, and were then given 10 trials on a transfer list (described below). The pairs in OL consisted of eight numbers (2 through 9) as stimuli, and eight different states of the U.S. as responses. When context stimuli (single letters) were used in OL, they were shown with the numbers

on study trials, and were absent on test trials. The letters appeared half of the time above and half of the time below the numbers. Ss were fully instructed about the nature of the study and test trials, and were told their task was to call out the name of the appropriate state when each number was shown alone on test trials.

For convenience in discussion, two sets of first-list associations will be defined: (1) primary associations (the pairs which S is instructed to learn, number-state), and (2) contextual associations (letter-state). At the end of OL, Ss were given a transfer task which consisted of eight letter-state pairs. The relationship between the contextual associations in List 1 and the letter-state pairs in List 2 will define the four conditions. Group I was an A-B, A-B group: the letters from List 1 became the primary stimuli in List 2, and each letter was paired with the response with which it had appeared on study trials in OL. Group II was an A-B, A-Br group: the letters from List 1 became primary stimuli in List 2, but each letter was paired with a state from List 1 *other than* the state with which it had appeared on study trials in OL. Group III was an A-B, C-D group: The letters which were used as context stimuli in List 1 were replaced with different letters for primary stimuli in List 2, and the states from List 1 were replaced with different states in List 2. For Group IV, there were no letters present in OL on either the study or test trials, but the first-list task was otherwise the same as for the other groups. Group IV was run in order to investigate the effect of letters as context stimuli on speed of OL. Group IV was also given the transfer task, and the paradigm is most similar to Group III, A-B, C-D, with the exception that the A-terms, a set of different letters, had not appeared at all during first-list learning.

There were four different transfer lists and each list was used equally often in each group. Four corresponding lists for OL were constructed for each group to form the required transfer paradigm. Lists were presented on a Stowe memory drum at a 2-sec. rate with a 4-sec. intertrial interval. Alternate study and test trials were used. Four different orders of presenting the pairs were used equally often as starting orders. Ss were undergraduates at the University of California, Berkeley. They were assigned to groups in blocks of 4, with each group represented one time in each block. The assignment to groups, lists, and starting orders was determined by a table of random numbers. There was a total of 16 Ss in each of the four groups.

Results and Discussion

Original learning. The mean numbers of trials to criterion in OL ranged from 8.3 to 10.5, and there were no significant differences among groups ($F < 1.00$, $df = 3/60$). Thus, there is no evidence that the learning of number-state pairs was facilitated by the addition of a context cue on study trials. It may be that the colors used as context cues by Saltz (1963) were effective because they provided more salient cues than did the letters used in the present study. However, other important differences between the two studies should be noted: (1) Materials—word-nonsense syllable pairs vs. number-state pairs to be learned, and (2) Measure of learning—number correct on a constant number of trials in OL vs. number of trials to criterion.

Transfer. Although the context cues made no difference in speed of acquisition, performance on the transfer list shows that there was incidental learning with respect to the context cues and appropriate responses. There was a significant difference between groups in mean number of correct responses on the first trial of transfer ($F = 3.31$, $df = 3/60$, $p < .05$). Table 1 shows the mean number of correct responses on trial 1 and trials 1-5 on the transfer list. Group I (A-B, A-B) gave significantly more correct responses than did Group II (A-B, A-Br) on the first trial ($p < .05$, Duncan Multiple Range Test). Thus, when contextual associations from the first task become the primary associations in transfer, Ss show better performance than when the context cues and response terms are re-paired on the transfer task. Group III (A-B, C-D) was intermediate between Groups I and II, but did not differ significantly from either group ($p > .05$). It is interesting to note that Group IV, which had no con-

text stimuli (i.e. no letters) during OL, did as poorly as did Group II (A-B, A-Br) on the first trial of transfer. It had been expected that Group IV would be closest (in transfer) to Group III, since the transfer paradigm in Group IV is closest to the A-B, C-D paradigm. The superior performance of Group III suggests that there is some beneficial effect of either (1) having a compound stimulus on study trials in OL, or (2) having some exposure to letters during OL.

For mean number correct on trials 1 through 5, there was also a significant difference between groups ($F = 4.08$, $df = 3/60$, $p < .05$), and the comparison between Groups I and II falls short of significance ($.05 < p < .10$, Duncan Test). The acquisition curves showed convergence during transfer, and when total correct over all 10 trials is considered, there are no significant differences between groups ($F < 1.00$).

Early performance on the transfer task shows that associative connections were formed between context stimuli and appropriate responses during OL when context stimuli were not present on test trials. It should be noted that the associations may be direct (letter-state), or may be mediated (letter-number-state). These results indicate that the possible role of associative factors in the "Context-No Context" condition must be further investigated before differences in learning with context cues can be attributed to the acquired distinctiveness of stimuli.

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Note

1. This study was carried out at the Institute of Human Learning, University of California, Berkeley. The research was supported by a USPHS Postdoctoral Fellowship (MH13, 474).

Table 1. Mean number of correct responses on the transfer list

Group	Trial 1	Trials 1-5
I	3.8	29.4
II	2.4	25.0
III	3.2	28.0
IV	2.4	26.6

The influence of eye movements on a new type of apparant visual movement¹

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When the sides of a contour triangle are sequentially presented, Ss report a sequential "flow" of brightness within the sides or a sequential "growth" of the sides. Modal report of this movement occurs in all three sides when the inter-side intervals are equal and 100 msec. Increasing the probability of contour scanning eye movements leads to an increase in this type of apparant visual movement.

From studies dealing with beta and gamma movement, it has been argued that eye movements do not influence apparant visual movement (Bartley, 1963; Guilford & Helson, 1929; Hulin & Katz, 1934; Wertheimer, 1912). A type of apparant visual movement is reported here which is influenced by eye movements. This type of apparant visual movement, similar to both beta and gamma, was noted by Ss in a number of studies which employed a method of sequentially presenting the sides of a contour triangle (McFarland, 1963, 1964a,b, 1965). Ss frequently reported "flow" or "growth" in one or several of the lines, viz., "the line appears in its entirety all at once but within the line there is a brightness which flows from one end to the other" or "one end of the line appears and then grows into the complete line." Ss also reported that "flow" and "growth" occurred from both ends toward the middle of a line or the reverse.

Method

To test whether eye movements affect this type of movement, one of three observation instructions is employed for each of three independent groups of eight Ss. These instructions are selected on the assumption that they differentially affect the probability of contour scanning eye movements during observation: (a) "fixate the small red light," (b) "try and look straight ahead," (c) "try and scan the lines."

The stimulus is an equilateral, contour triangle (Fig. 1A). Sides are presented for 10 msec. each in CCW sequence, 1 2 3. The two inter-side intervals are maintained equal and varied on different trials from 0-300 msec. in 25 msec. steps. Ss are dark adapted for 10 min. and receive five trials on both an ascending and a descending series at each inter-side interval, a total of 130 trials for each S (see McFarland, 1965, for details).

Results

There were reports of "flow" or "growth" on 20% of the total 3,120 trials for the three groups. Movement was reported in one, two, and three sides, either unidirectional or bidirectional. Three types of unidirectional movement occurred: CCW, movement com-

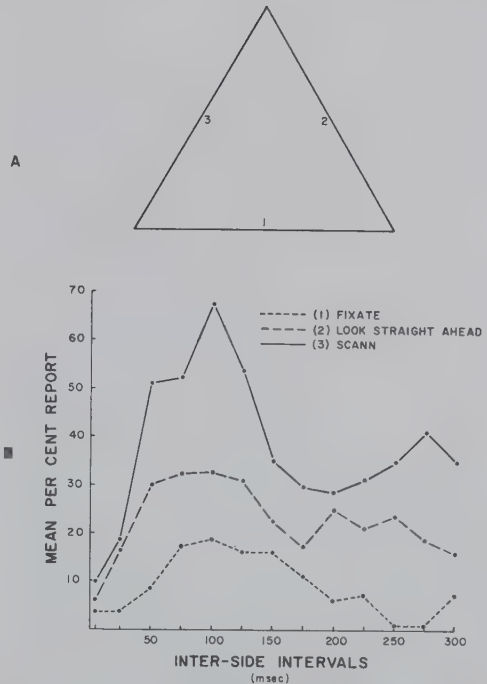


Fig. 1A. The stimulus is presented straight ahead, at eye-level, in a fronto-parallel plane, 17 in. from the S. Each side is 1 degree in length and approximately .44 ft. lamberts. For group 2, the red fixation light appears at the center of the triangle. B Mean % movement report for the three observation groups as a function of inter-side intervals.

menced at the left end of side 1 and proceeded to the right, or commenced at the bottom of side 2 and proceeded up, or commenced at the top of side 3 and proceeded down; CW, the reverse of CCW; and CCW and CW, a combination. Two types of bidirectional movements occurred: from the center of the line to the ends; from the ends of the line to the center. Bidirectional movement was always, when reported in more than one line, CCW and CW.

The modal report was CCW, unidirectional movement ($F=59.58$, $p<.01$) in all three sides ($F=2.97$, $p<.01$) at an inter-side interval of 100 msec. ($F=2.86$, $p<.01$). At this inter-side interval, over 50% of the reports from other Ss are that some of the sides appear unjoined at their ends and the sides appear in perfect succession (McFarland, 1965).

Effects of observation instructions on all movement

Table 1. Types of movement reports as a function of observation instruction (frequency).

	Unidirectional movement			Bidirectional movement
	CCW	CW	CCW and CW	Combined center-ends and ends-center
Fixate	84	10	4	0
Straight ahead	167	7	5	56
Scan	158	99	9	22

reports can be seen throughout the range of inter-side intervals tested ($F < 1.00$) (Fig. 1B). Instructions have their particular effect on the direction and type of movement (Table 1). Both "try and look straight ahead" and "try and scan the lines" increases the report of CCW, unidirectional movement ($F = 5.21$, $p < .01$). Instructions to "try and scan the lines" also increases the report of CW, unidirectional movement ($F = 6.80$, $p < .01$).

Discussion

In considering these effects of observation instructions, it is evident there are two avenues whereby an increase in contour scanning eye movements could lead to the observed increases in this type of apparent visual movement. First, eye movements could displace the stimuli on the retina; and, second, signals from central efferent and/or peripheral afferent structures of the extra-ocular motor system could interact with retinal signals (Grüsser & Grüsser-Cornehl, 1961). As eye movements are not monitored in the present experiment, however, a clear-cut decision in this regard is not possible. On the basis of the present experiment, it can only be said that, since the modal frequency of this type of movement occurs when inter-side intervals approximate the latency for a saccadic eye movement (Bartz, 1962; Ditchburn & Ginsborg, 1953; Nachmias, 1959; Ratliff & Riggs, 1950; Tinker, 1953; Westheimer, 1954), it is likely that when eye movements do occur, they occur during the inter-side intervals when no side is visible. If future work shows that this is indeed the case, then it would seem plausible to argue that signals from central efferent and/or peripheral afferent structure of the extra-ocular motor system are interacting with retinal signals at

some site within the nervous system to produce the increase in this type of movement. The plausibility of such an argument is enhanced by the fact that interaction of extra-ocular motor and retinal signals has already been found to affect the visibility of retinal signals (McFarland, 1964c).

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Note

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Associative factors in the recall of connected discourse^{1, 2}

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Two passages, one of which contained words of high associative strength and the other words of low associative strength, were presented once by tape recorder and followed by a written recall test. On all measures of recall, performance in the high association group was superior to performance in the low association group. The results of a cloze test suggested that guessing may have contributed more to recall scores in the high association group than the low association group.

Since, when words are associatively related, recall tends to be facilitated in the case of lists of words (Deese, 1959) and lists of word sequences (Rosenberg, 1965), it is reasonable to expect that the presence of associative relationships between words will facilitate the recall of connected discourse (a series of inter-related sentences) as well. The present study was designed to evaluate this hypothesis in the case of the recall of content words in a short narrative. An attempt was made, also, to determine, through the use of a cloze procedure, the extent to which recall scores for such materials might be influenced by guessing from context, as has been suggested by Deese (1961).

Subjects

Two classes of undergraduate students in educational psychology ($N=24$ and 30) were divided in half at random and the halves in each class were randomly assigned to either the high associative strength (HA) discourse or the low associative strength (LA) discourse.

Materials

In preparing the HA discourse, stimulus and response words (mostly nouns and adjectives) were selected from the New Minnesota Norms (Palermo & Jenkins, 1964) and made part of the content of the narrative. For each stimulus word, there were in the discourse from one to five responses of appreciable strength. In preparing the LA discourse, items that were designated as response words in the HA passage were replaced by items with the following characteristics: (1) very low (virtually zero) in associative relationship to the stimulus word; (2) comparable in T-L frequency; (3) appropriate semantically in the context of the discourse; (4) comparable grammatically. The two passages contained the same stimulus words and were identical in length.³ The passages were recorded on magnetic tape.

Procedure

The data for each condition were collected in two sessions in a group-testing situation. The N was 12 for the first session of each condition and 15 for the

second. There was a one-trial presentation of each passage followed 4 sec. later by a 7-min. written recall test. The presentation time for each passage was approximately 63 sec. The Ss in each group were told to try to remember as much of the passage as they could, and, for the recall test, to write down as much of the passage as they could recall and to try to guess at items they were not sure of.

Results and Discussion

Since the differences between LA and HA were comparable for both sessions, the data from the two sessions were combined. In scoring recall, the location of an item was not considered. There were 16 possible stimulus words and 16 possible R-1 words. In the HA discourse, the R-1 word for each stimulus word was the strongest response word according to the norms, and in the LA discourse, it was the low-strength counterpart. Since some stimulus words had more than one response, another measure of recall, R-2, was computed based upon the total number of response words recalled.

The mean number of stimulus words and R-1 words recalled in Group HA were, respectively, 9.26 ($SD=3.17$) and 8.07 ($SD=2.96$), and in Group LA, 7.22 ($SD=2.58$) and 4.78 ($SD=2.78$). An analysis of variance revealed an $F=14.10$, $df=1/52$, $p<.001$, for associative strength and an $F=33.33$, $df=1/52$, $p<.001$, for stimulus words vs. R-1 words. The interaction was nonsignificant. In general, it can be seen that recall of stimulus words and R-1 words from the HA discourse was significantly higher than recall of stimulus words and R-1 words from the LA discourse. In addition, for both passages, significantly more stimulus words were recalled than R-1 words. Possibly, there were greater contextual constraints for the stimulus words in the passages than for the R-1 words.

The mean number of R-2 words recalled in Group HA was 13.00 ($SD=3.98$) and in Group LA, 7.85 ($SD=4.30$). The t -test comparison of these means resulted in a $t=4.56$ ($df=52$), which was significant beyond the .001 level (one-tailed). A t -test was also made for the comparison of the mean number of stimulus and R-1 word pairs recalled. Group HA recalled on the average 6.15 ($SD=3.01$) such pairs, and Group LA, 3.04 ($SD=2.62$). The value of $t=4.09$ ($df=52$) was also significant beyond the .001 level (one-tailed).

The recall dependencies between stimulus and R-1 words, and between R-1 and stimulus words were also analyzed. The question that was asked, in the case of, for example, the stimulus word, R-1 word contingencies

was what proportion of the stimulus words recalled were accompanied by their appropriate R-1 words on the recall sheet. The mean S-R dependencies in Groups HA and LA, respectively, were .64 (SD = .22) and .40 (SD = .24), and R-S dependencies, .72 (SD = .25) and .56 (SD = .24). The stronger dependencies in the R-S direction were most likely the result of the higher level of recall of stimulus words. An analysis of variance of these data revealed an $F = 9.40$, $df = 1/52$, $p < .01$, for associative strength and 25.75, $df = 1/52$, $p < .001$, for directionality. The interaction was nonsignificant.

These results suggest strongly that associative habit plays an important role in the recall of connected discourse. In trying to account for the observed facilitation, one possibility considered was guessing habits. If, during written recall, an individual tries to guess at words, his guessing behavior is likely to be influenced by the items he has already recalled. Associative theory would predict that what he does guess will frequently be a high strength associate of a recalled item. Now, if that high strength associate is part of the original material he is trying to recall, his recall score will be enhanced.

In an attempt to evaluate this possibility, the HA and LA passages were printed on sheets of paper and presented to Ss who had not participated in the learning study. There were four groups of 15 Ss each, and the groups were differentiated in terms of whether they received the HA or the LA discourse and whether the stimulus words or the R-1 words were deleted. The Ss' task was simply to guess at the missing items. The data were collected in a group-testing situation and all Ss were permitted to complete the task.

The Ss given the HA discourse guessed correctly on the average 8.47 (out of 16) of the stimulus words and 7.87 of the R-1 words, while the Ss given the LA discourse had a mean of 4.00 for the stimulus words and .20 for the R-1 words. Guessing scores were clearly higher in the case of words deleted from the HA discourse. Since the LA discourse contained the same stimulus words as the HA discourse, the wrong guesses by Ss in Group LA were examined to determine whether any high strength associates had occurred. The mean number of R-1 words from the HA discourse guessed by Ss in Group LA was 7.93.

This last finding suggested that Ss in the recall study in Group LA should have also produced some high associative strength words. In scoring the recall protocols for this factor, it was discovered that LA Ss had produced during recall a mean of 3.30 high strength responses.

In view of these findings, it is possible that performance in the recall study may have been more

a function of guessing in the case of the HA discourse than the LA discourse. This is not to say, however, that other factors were not involved. It is possible, for example, that during presentation of a passage, when a stimulus word occurs, it tends to elicit, implicitly, some of its associates, and in the case of the presence of bidirectional strength, if the associates occur in the same passage, they may tend to elicit, implicitly, the stimulus word. What this would mean, essentially, is that the frequency of occurrence (overt + implicit) of associatively related words would be greater than would be the case for words of low associative strength, with the possible result that recall of an HA discourse would be facilitated. Some evidence for the possible operation of implicit associative responses in verbal behavior has been presented recently by Underwood (1965).

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Notes

1. This study was supported by grant MH 08904-02 from the National Institute of Mental Health, U. S. Public Health Service.
2. Based upon a paper presented at the Psychonomic Society meeting, Chicago, October, 1965.
3. *HA discourse*—The tall man sat on a chair in front of a low table, while the pretty woman played soft music on the piano. The table was piled high with food. There was cheese and crackers, bread and butter and some cold fruit and a hot vegetable as well. A young girl sat on the floor on the yellow carpet reading a book, while a small boy played with some toys on a blue rug in the middle of the room. The man was a soldier in the army and had just returned from the war that day. Although there had been much to eat on the train, the sight of all that food made him hungry again. The atmosphere was one of joy. They were all happy to be together again. Outside the moon and stars shone brightly in the June sky, and the green grass sparkled in the night.
4. *LA discourse*—The dark man sat on a pillow in front of a small table, while the gentle lady played good music on the organ. The table was piled high with things. There was cheese and salad, bread and juice and some cold fruit and a dry meat as well. A fine girl sat on the blanket on the yellow carpet reading a book, while a small dog played with some toys on a purple cloth in the middle of the room. The man was a soldier in the draft and had just returned from the field that day. Although there had been much to taste on the train, the sight of all that dinner made him hungry again. The atmosphere was one of joy. They were all relieved to be together again. Outside the moon and lake appeared clearly in the June evening, and the green house sparkled in the valley.

Vestibular sway: Parameters of the eliciting stimulus

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Postural sway was elicited in human Ss using various combinations of low frequency-low amplitude sinusoidal electrical stimulation at the mastoid processes. Amount of sway was a V-shaped function of the stimulus frequency at low amplitude and an inverted V function at the higher amplitude. Amplitude-frequency combinations optimal for eliciting overall sway were different from those most suitable for use in conditioning.

Recent experiments have indicated that low frequency sinusoidal electrical stimulation of low amplitude applied to the human vestibular apparatus elicits postural sway and that this response can be conditioned (Revusky et al, 1965). Dzendolet (1963) found that thresholds of vestibular sway depend upon stimulus frequency. The present experiment investigated the joint effects of stimulus frequency and amplitude in the context of a classical conditioning situation.

Method

Postural sway was recorded by having the S stand on a low platform supported by a steel fulcrum and two steel bars. Lateral sway exerted force on one underlying steel bar while withdrawing force from the contralateral bar. Strain gages affixed to these bars formed two legs of a Wheatstone bridge, the output of which provided a continuous oscillographic record of lateral sway. The platform was quite stable and provided little sensation of rocking. The apparatus and general procedure are described in greater detail in Revusky et al (1965).

Ss were blindfolded and remained standing on the platform for the entire experimental session. They were instructed to maintain a standard posture: feet together, knees relaxed, equal weight on both legs, and hands clasped in front. The purpose of the experiment was described as "recording brain waves to sounds under mild stress." These instructions presumably explained the presence of the fluid electrodes on the Ss' mastoid processes and the requirement of standing for a long period of time, while masking the true purpose of the experiment. Each S received 3 initial trials consisting of presentation of the conditioned stimulus (CS) alone. This was a 1000 cps tone of 70 db SPL and of 5.5 sec. duration. These trials were followed by 8 blocks of trials which, for conditioning groups, consisted of 3 trials on which the CS was paired with the unconditioned stimulus (UCS) followed by a test trial consisting of presentation of the CS alone. The CS-UCS interval was a constant .5 sec. on conditioning trials. The UCS was a 5 sec. sinusoidal electrical stimulus of either .2, .5, and 1.0 cps at either high

or low peak amplitudes of .27 and .12 milliamperes. These levels of stimulation are too low to seriously threaten the S's equilibrium, and, in fact, most Ss remained unaware of their swaying or the UCS.

Twelve male undergraduate volunteers were randomly assigned to each combination of UCS amplitude and frequency, thereby completing a 2 by 3 factorial design. A control group, comprised of an additional 12 Ss, received the same number of CS presentations as the conditioning groups, but the UCS was never presented. The intertrial interval was a constant 70 sec., and all Ss were allowed a brief period halfway between each trial to stretch and readjust their posture. A continuous white masking noise of 70 db SPL was on for the entire experimental session.

Response amplitude was measured as the difference between the greatest positive and negative excursions of the oscillographic recording pen within a specified scoring interval. There were two scoring intervals for each trial: a pre-trial score was obtained from the 5.5 sec. interval immediately before CS-onset and an on-trial score was obtained from the 5.5 sec. while the CS (or CS plus UCS) was on.

Results and Discussion

Analysis of variance of amplitude scores showed that the six conditioning groups did not differ over the 3 initial test trials. Furthermore, all groups showed a gradual increase in both pre- and on-trial response amplitude over trials which was likely due to cumulative fatigue. The difference in response amplitude between the first and second halves of the experiment was significant, $F(1,66) = 39.92, p < .001$.

Figure 1 shows the mean response amplitude for each group pooled over trials.² With the lower amplitude

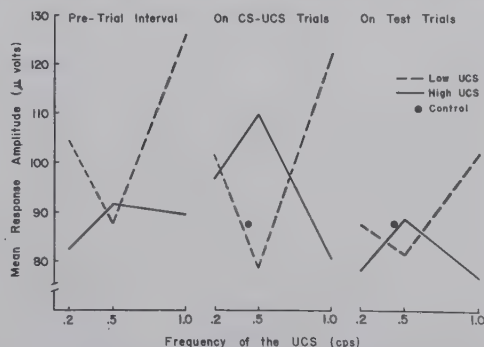


Fig. 1. Mean response amplitude for each group during pre-trial interval, on conditioning (CS-UCS) trials, and on test (CS-alone) trials.

UCS, both pre- and on-trial sway was a V-shaped function of UCS frequency. The rank order of frequencies in terms of response amplitude was 1.0, .2, and .5 cps from greatest to least. Increasing the amplitude of the UCS produced a complete reversal of this rank order, with sway to 1.0 and .2 cps greatly suppressed while that to .5 cps was enhanced, especially during the on-trial intervals. This pattern suggests (a) that the vestibular apparatus is more sensitive to frequencies of .2 and 1.0 than .5 cps, a conclusion which agrees with the thresholds for vestibular stimulation at various frequencies determined by Dzendolet (1963), and (b) that excessive vestibular stimulation engenders compensatory mechanisms which inhibit postural sway. Presumably, then, further increases in the amplitude of a .5 cps stimulus would also have resulted in suppression of sway.

Figure 2 is a plot of the mean differences in response amplitude between pre- and on-trial intervals. Positive

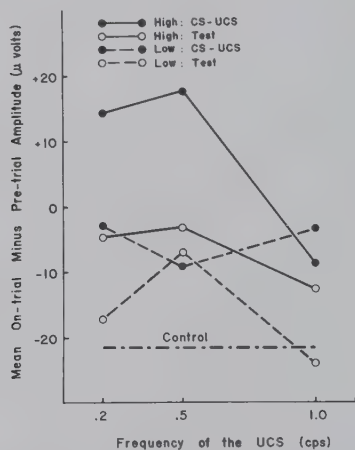


Fig. 2. Mean amplitude difference (on-trial amplitude minus pre-trial amplitude) for conditioning (CS-UCS) trials and test (CS-alone) trials for each group.

scores indicate that on-trial amplitude exceeded the pre-trial level. Figure 2 shows that the CS tended to produce response suppression relative to pre-trial sway, presumably as a component of an alerting or orienting response. The fact that this suppression was greatest in the control group indicates that a UCS must overcome this suppression before a well defined response can occur.

In conditioning work the UCS (and CR) are usually defined and measured relative to a pre-trial or baseline level. Figure 2 suggests that a UCS of .2 or .5 cps of high amplitude should be optimal for conditioning experiments since groups receiving these combinations of frequency and amplitude showed the most clearly differentiated responses to the eliciting stimulus.

We conclude that mild electrical stimulation of the vestibular apparatus elicits slight changes in equilibrium and causes bodily sway. With excessive vestibular stimulation, however, sway becomes inhibited, presumably by way of somatic and proprioceptive feedback mechanisms which compensate for disturbances of equilibrium. This experiment might guide future investigators in selecting intensity and frequency values of the electrical stimulus. The optimal stimulus values selected will be different for conditioning work than for studies of overall postural sway.

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Notes

1. Now at Indiana University.
2. Significance levels for the difference between any two means plotted in Fig. 1 were obtained from *t* tests based upon the "error" mean square for the third order interaction from analysis of variance. This UCS frequency by UCS amplitude by Score interval (pre- vs. on-trial) by Trial type (conditioning vs. test trial) interaction was significant ($p < .025$). Differences between means greater than $16.7 \mu V$ and $22.2 \mu V$ were significant at the .05 and .01 levels, respectively.

Free word associations of children and adults¹

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Free word associations of children and adults are compared to test the theory of three phases in intellectual development. Children (ages 3-4) gave significantly more "primitive" associations to 22 common nouns; adults (ages 19-24) evidenced a greater tendency to use abstract or "logical" relationships. Both groups gave an approximately equal number of the intermediate "physical" response. Implications for the general theory and the relationship to language acquisition are discussed.

Current theories of intellectual development, strongly influenced by Piaget, typically describe three levels of conceptual orientation (cf. Watson, 1959). The first level might be termed "primitive" since words are used in socially meaningless and/or uniquely personal ways. The older child functions at an intermediate or "physical" level; he understands and organizes words on the basis of physical or infralogical characteristics, e.g., their attributes and functions. Finally, the adult level is marked by "logical" or abstract relations with roots in the formal grammatical rules of our culture.

This study tests the general theory by analyzing the differences among these three levels in free word associations (FWA) of children and adults.

Method

Two groups of Ss provided the independent variable of age: (1) 12 children from predominantly middle-class nursery schools, 6 of age 3 and 6 of age 4; (2) 12 students at the University of Michigan, ranging in age from 19 to 24. Both groups contained an equal number of males and females.

The stimulus words used to elicit FWA were 22 common nouns (Riegel, Riegel, Smith, & Quarterman, 1964): table, man, house, butterfly, chair, river, window, carpet, girl, cabbage, stomach, bread, boy, cottage, head, child, city, doctor, bed, moon, cheese, and street. Responses were classified, independently by two coders, into 20 categories adapted from Riegel et al (1964) and from Woodworth (1938). The 20 differentiated relationships of FWA to noun-stimulus grouped themselves, both by content and by empirical trends, into the following more inclusive categories (with absorbed classifications in parentheses):⁴

I. Logical (Superordinate; subordinate; coordinate, similar, or contrast)

IIA. Physical—structure (Whole; part; location)

IIB. Physical—contingency (Activities by stimulus; activities done to or with stimulus; qualities)

IIC. Physical—contemporaneity (commonly related to stimulus in experience, but not I or IIA, B)

IIIA. Primitive—subjective (personal or proper names; evaluation; emotion)

IIIB. Primitive—unrelated ("triggered" responses; no common relation)

IIIC. Primitive—form-determined (clang associations; completions)

IIID. Primitive—no response ("I don't know"; no response; stimulus repeated)

Each S was tested individually. Four practice stimuli were administered first; after S's sample responses, E approved and, with child Ss only, noted other possible replies designed to vary in parts-of-speech. Then the 22 experimental words were randomly presented with a 20-sec. limit for responding. With the child Ss, the stimuli were phrased, "If I say (stimulus) to you, what would you say to me?"

Results

A total of 528 responses were coded into the 20 separate categories with an intercoder percentage agreement of 89%. For the three major categories (I, II, III), percentage agreement reached 95%. Disagreements were discussed until consensus was obtained.

Table 1 gives the results by age and sex for the groupings described above. Although some intriguing possibilities exist within subclass, the major trends are clearly in the major categories summarized in Table 2. The average child exhibits many more primitive responses while the average adult produces more of the logical type ($\chi^2=12.39$, $p<.01$). Very little difference exists in the physical class.

Table 1. Frequency of FWA in Each Class

	I	IIA	IIB	IIC	IIIA	IIIB	IIIC	IIID
Age 3								
Male (N = 3)	2	4	16	6	1	16	19	2
Female (N = 3)	6	7	5	9	1	31	3	4
Age 4								
Male (N = 3)	17	7	6	9	4	18	1	4
Female (N = 3)	6	8	5	12	4	26	2	3
Adult								
Male (N = 6)	70	17	19	19	0	3	4	0
Female (N = 6)	55	21	24	19	3	1	9	0
Totals								
Children (N = 12)	31	26	32	36	10	91	25	13
Adults (N = 12)	125	38	43	38	3	4	13	0

Table 2. Average Frequencies for Major Categories

	Logical (I)	Physical (II)	Primitive (III)
Child	2.58	7.83	11.58
Adult	10.42	9.92	1.67

Discussion

The results generally support the commonly presented theory of the development in concept orientation. The very young child—in this case, a mere year or two beyond the first word—tends to exhibit primitive relationships between stimuli and FWA. His associations show more personal and more sound-determined orientations, both of which are relatively less sociocentric than other types. The high frequency of unrelated responses is similarly indicative of the lack of formal organization in the child's orientation. Children, in addition, are more likely to find themselves unable to produce any association to a word.

Adults, on the other hand, give considerably more responses that are "logical"; i.e., involving abstract relationships prescribed by formal language rules. Such a finding suggests that the development of concept orientation closely parallels the course of language acquisition, an assumption underlying the current trend in purely linguistic coding schemes (Brown & Berko, 1960; Ervin, 1961; Entwisle, Forsyth, & Muuss, 1964).

The fact that children, if their response was not primitive, usually gave physical associates is also of interest. We had conceived the physical class as one primarily developed in the course of everyday observa-

tion; i.e., the action verbs, the descriptive adjectives, and the denotative nouns relating objects commonly experienced together. The finding has obvious significance for theories providing for an early "syntactic" language learning as opposed to later "paradigmatic" development (Ervin, 1961; Entwisle et al, 1964).

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Notes

1. Appreciation is extended to Dr. K. F. Riegel for his aid and comments.
2. Now at Brookwood Child Care Agency, New York City.
3. Now at Stanford University.
4. The complete coding scheme, with explanations, examples, and results by subdivision, is available from the junior author.

Verbal conditioning with "positive" and "positive and negative" reinforcement

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To test the hypothesis that "positive" (+ only) and "positive and negative" (+ & -) reinforcement schedules will affect conditioning of a random noun schedule, 30 Ss were randomly selected and placed into 3 groups (control, + only, and + & -). The nouns to be conditioned were of the animate form where conditioning was done by generalized conditioned reinforcers "mmm-hmm" for the positive and "huh-uh" for the negative. The results support the hypothesis that with the (+ & -) reinforcers the group conditioned significantly faster than with (+ only) and this faster than the controls.

Skinner has commented that one of the principal effects of punishment upon verbal behavior is "...to convert the behavior, ..., into a conditioned aversive stimulus. Any behavior which reduces such stimulation—such as any behavior which is incompatible with or otherwise displaces punished behavior, either in its incipient or final stages—is automatically reinforced. In punishing one response, then we automatically provide for the reinforcement of responses which are incompatible with it" (Skinner, 1957, p. 166).

If it may be assumed that positive generalized reinforcers do strengthen the probability of occurrence of a particular class and if negative generalized reinforcers, in addition, provide for reinforcement for responses which are incompatible with it, it may be hypothesized that (+ & -) reinforcement will have greater influence upon verbal behavior than the (+ only) reinforcement.

Procedure

A random selection of 30 Ss was taken from the population of 1420 students at Central Washington State College during the summer term of 1965 having sophomore through senior status. The 30 Ss were randomized into three groups having 10 Ss in each, where Group I was the control group having no introduction of reinforcement, Group II was on a positive (+ only) reinforcement schedule, and Group III a positive and negative (+ & -) reinforcement schedule was used.

The experiment was conducted in a small, sound proof room. Within the room were two chairs and a desk. The desk and one chair faced the wall where the S was instructed to be seated. The E was seated behind and out of sight of the S. On the desk, in front of the S, was a timer marked off into 10 sec. intervals, which was his rate schedule for word verbalizations.

The S was given the following instructions at the beginning of the experiment: "What I want you to do is to say randomly all the nouns or words that can be used as nouns that you can think of. Do not use any

sentences or phrases. Do not count. Say them one at a time as the time hand passes the designated intervals on the timer face. Continue until I say 'Stop' and as soon as I say 'Start' go ahead."

The experimental sessions were 20 min. in length. For the Ss of each group, the first 5 min. included no reinforcement in order to obtain a proportionality factor of the animate to inanimate nouns and to determine whether there was any appreciable set involved which might affect the results. The Ss in Group I received no reinforcer for each of their responses, those Ss in Group II received only a generalized positive reinforcer, "mmm-hmm," following each animate noun that was emitted, and Ss in Group III following each animate noun were given a generalized positive reinforcer, "mmm-hmm," and when an inanimate noun was emitted, the S received a generalized negative reinforcer, "huh-uh."

In reference to the subject verbalizations and to the reinforcement patterns, the defined word groupings were as follows: (1) animate nouns were those having life qualities such as girl, dog, cat, song, etc. and (2) inanimate nouns were any words not having life qualities, stone, car, river, etc. Any word about which there was any question as to whether it was animate or inanimate was designated as inanimate.

In order to ascertain if the S had knowledge of what was the purpose of the experiment, the S was asked what he thought the experiment was all about at the end of the experimental period. In no case was it necessary to replace a S due to such knowledge.

Results and Discussion

The relationship of the proportions and set to the results of the first 5 min. were found to be not statistically appreciable. For the purpose of statistical analysis, the last 5 min. of the experiment were utilized. It was observed that there were significant differences between the treatment effects ($F=14.496$, $df=2/27$, $p<.01$). The Duncan multiple range test was used to determine the significant differences between the groups. The results showed a significant difference at $p<.01$ between the mean value of the control group ($\bar{X}_1=10.4$) and the mean of the (+ only) group ($\bar{X}_2=23.6$) and of the (+ & -) group ($\bar{X}_3=44.4$). Likewise, the Duncan test showed a significant difference with the $p<.01$ between the (+ only) and the (+ & -) groups.

The basic general conclusions that may be drawn from the results of this study are in support of the hypothesis. Positive reinforcement increases the prob-

ability of the response but that the rate and magnitude of the responses are significantly greater when both positive and negative reinforcement are utilized.

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Abstract

Levy, C. Michael (U. Florida). Effect of intrastimulus agreement and conflict upon conditioned discrimination and reversal of the eyelid response. *J. exp. Psychol.*, in press—Agreement and conflict within conditioned stimuli were manipulated by presenting two groups with the words PINK and BLUE written in appropriate and inappropriate colors, respectively. Control groups were presented with these words or colors. Sixty differential conditioning trials were given to all Ss. Half of the Ss in each group were given 40 reversal trials; the remaining Ss were not reversed. Intra-CS conflict produced poor discrimination of the eyelid response by elevating the CS- function. It was speculated that a cognitive interpretation might well account for the empirical asymmetries since most Ss met the voluntary responder criterion and could verbalize many of the crucial experimental arrangements. (Pre-publication copies of the manuscript are available from the author.)

The effects of "instructions to mediate" upon paired-associate learning¹

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Ss were given two paired-associate lists to learn at either the first, third, or text orders of approximation to English. One-third of Ss at each order received "mediating" instructions between the two lists, another third received "motivating" instructions, and the remainder simply rested. Mediating instructions facilitated second list learning at higher orders of approximation, but the effect was only obtained with relatively unmotivated Ss. When highly motivated Ss were used, there was little difference among the three groups.

Most experiments concerned with the effects of mediation upon paired-associate learning have employed an A-B, B-C, A-C paradigm, in which a mediating link (B) is used to bridge two previously independent verbal units (A and C). When subsequent A-C learning in this paradigm is compared with that of various control groups, a facilitative effect due to the previous A-B, B-C learning is often found. Many experiments (e.g. Horton & Kjeldergaard, 1961) attribute this effect to "mediation." Others (e.g. Mandler & Earhard, 1964; Earhard & Mandler, 1965) have argued that the effect is an artifact and can be explained in terms of simple interference and forgetting mechanisms. The present study was based on the premise that, if mediation does have a facilitative effect, then Ss who have received instruction in how to mediate should learn a list of paired-associates faster than Ss who receive no such instructions.

Experiment 1

Method

Thirty-two different eight-letter sequences at each of the first, third, and text orders of approximation to English were taken from an earlier study (McNulty, 1965) and used as stimulus (S) items for the paired-associate lists. For response (R) items, 32 eight-letter nouns and adjectives from the A and AA frequency ranges were chosen at random from the Thorndike-Lorge word count. Words of high frequency were used as R items in all of the lists so that Ss would have to do little response learning. The 32 R items were then randomly paired with the 32 S items of each order of approximation. The 32 pairs thus formed at each "order of approximation" were randomly divided into two lists of 16 pairs each.

Each S was given both of the paired-associate lists at a particular order of approximation to learn. Items were presented on a memory drum at the rate of 3 sec. per S item and 2 sec. per S-R pair. Learning on each list was to a criterion of two perfect consecutive repetitions. Four random orders of each list were used, the four being typed on a single tape and run continuously until S had reached the learning criterion.

Ss were 54 women between the ages of 17 and 24 who were taking an introductory course in psychology. They were randomly assigned to nine groups of six Ss each. Three of these groups learned the paired-associate lists from the first order of approximation, three learned the third order lists, and the other three learned the text order lists. The order of presentation of the two paired-associate lists at the appropriate order of approximation was counterbalanced over Ss within each of the nine groups.

Before the first list was presented, standard instructions for paired-associate learning were given. After the learning criterion had been reached on the first list, there was a 3 min. break before the second list was presented. During the break, one of the three groups at each order of approximation simply rested. Another received "motivating" instructions which urged Ss to concentrate and try harder to learn the list. The third group received "mediating" instructions which told Ss, in effect, to form the most "ridiculous, bizarre, or ludicrous" mediating association they could between the S and R items of each pair. They were told, for example, that if the S (or R) item reminded them of something, they should try to link what it reminded them of with the other item of the pair, and the more unusual they made this linkage, the easier it would be to remember the pair.

Results

There were no significant differences among the three groups in the number of trials taken to reach the learning criterion on the first list. Each S's performance on the second list was expressed as a "savings" score. That is, the number of trials taken to reach criterion on the second list was subtracted from the number of trials taken to learn the first list, and the remainder was expressed as a percentage of trials to criterion on the first list. The mean savings scores for each group are plotted in Fig. 1.

Group I, which received no instructions during the 3 min. break between lists, shows the facilitative effects of "learning how to learn." When motivating instructions (Group II) were given, the per cent saved in learning the second list decreased slightly as approximation to English increased, as if the instructions had a "punishing" effect at the third and text orders. Perhaps Ss interpreted the motivating instructions as a criticism of their performance on the first list.

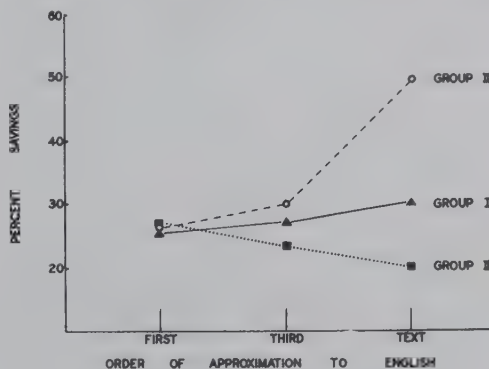


Fig. 1. Per cent savings at each order of approximation in learning a second list of paired-associates after being given no instructions (Group I), motivating instructions (Group II), or mediating instructions (Group III).

When mediating instructions were given (Group III), per cent saved in learning the second list increased with approximation to English.

As Fig. 1 shows, there was practically no difference among the three groups at the first order of approximation. Neither motivating nor mediating instructions had any effect. At third order, the differences were greater, but mediating instructions still resulted in little savings in second list learning compared to Ss who received no instructions at all. The differences among groups were greatest at text order and here mediating instructions resulted in a marked savings in second list learning.

To test the significance of these results, an analysis of variance was done on the savings scores. None of the effects were significant, primarily because of the high degree of variability among Ss in the number of trials taken to learn any list. A trial by trial analysis of number of correct responses also failed to yield significant results.

Experiments 2 and 3

Experiment 2 was an exact replication of Experiment 1 to determine whether the results of the first experiment were reliable, even though they failed to reach an acceptable level of significance. Fifty-four women from the same university population served as Ss. Results obtained in the second experiment were almost identical to those shown in Fig. 1. These results were again not significant by analysis of variance, again because of the high degree of inter-subject variability. However, since almost identical results were obtained, the phenomenon is probably a reliable one.

The fact that some Ss took so much longer to learn the paired-associate lists than other Ss in the same groups suggested to us that many of them were simply not trying very hard. For some time we have observed that many university students, even experimentally naive ones, have become very blasé about taking part in psychological experiments. Probably because of the repetitive nature of verbal learning experiments, most appear to become bored and disinterested after a very few minutes in the situation in spite of efforts to motivate them, and seem to be quite unconcerned about whether or not they learn the material at all. We wondered, therefore, whether the mediating instructions only had a facilitative effect because they gave relatively unmotivated Ss an easy and comparatively effortless way to learn the lists.

The experiment was therefore replicated a third time but using highly motivated Ss. Forty-five senior high school girls (five in each of the nine groups) between the ages of 16 and 20 served as Ss. Letters were sent to their parents, requesting their child's participation and stressing the importance of this type of research. Each parent was then phoned, questions were answered about the study without giving away its

purpose, and approval for their child's participation was obtained. Each girl was then contacted, her cooperation requested, and the importance of the study and her participation in it was again stressed.

Results of Experiment 3 showed that there was little difference in savings scores among the three groups. Group III showed greater savings at all orders of approximation than the other two groups but the differences were relatively small. The interesting thing was that both paired-associate lists were learned in one-third fewer trials on the average than those in Experiments 1 and 2, suggesting the Ss in Experiment 3 were indeed more highly motivated than those in Experiments 1 or 2.

Discussion

Bousfield (1961) has suggested that only words should be considered as appropriate vehicles for mediation, and Earhard & Mandler (1965) have pointed out that mediational effects generally cannot be obtained with material of low meaningfulness. The results of Experiments 1 and 2 are consistent with this position. The facilitative effect of mediating instructions was found to be a direct function of order of approximation. Of course, the fact that mediating instructions had little or no effect at low orders of approximation does not necessarily mean that Ss cannot use mediating associations to learn lower order lists. Nevertheless, it does suggest that other processes (e.g. simple contiguity, integration) are predominant.

Experiment 3 showed that when Ss are highly motivated to learn the paired-associate lists, giving them mediating instructions has little effect. Motivated Ss undoubtedly use a variety of "subjective" devices to learn the pairs including contiguity, integration, mediation, mnemonic aids, etc. The third experiment also emphasizes that one must be cautious about making general statements on the basis of results obtained in experiments which have used only college students as Ss.

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Note

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Effects of procedural variables upon reversal and interdimensional shift performance: I¹

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College Ss accomplished a reversal (R) shift faster than an interdimensional (IRD) shift over three different methods of problem presentation, when no cue cards were present. With cue cards present there was no difference between R and IRD shifts. The latter finding reflects an increase in the difficulty of the R shift resulting from the necessity for S to sort contrary to cue cards whenever a R shift is made.

In a previous study (Johnson, 1965) no difference in difficulty was found between R and IRD shifts in solution of concept identification (CI) problems. Moreover, performance on both types of shift was affected adversely and in equal amounts by increasing the number of irrelevant stimulus dimensions. These findings are contrary to earlier research (Kendler & Kendler, 1962) which has consistently reported better performance by adult human Ss on R as contrasted to IRD problems. An examination of experimental procedures revealed a number of variables that might have contributed to these discrepant findings and more generally to the magnitude of R-IRD differences. It was the purpose of this experiment to investigate systematically the influence of two of these variables, viz., the problem presentation mode and the availability of cue cards.

Method

The 144 male and female undergraduates were randomly assigned to the following conditions of a factorial design: Method of Stimulus (S), Response (R) Presentation—1S-1R, 1S-2R, or 2S-1R; Cue Card—Present or Absent; Dimensions—2 or 4 irrelevant; Type of shift—R or IRD; and Problem—Color or Size dimension relevant during the preshift phase. In Condition 1S-1R and 1S-2R the stimuli were presented individually; under Condition 2S-1R S was instructed to respond only to positive instances of the concept, while under Condition 1S-2R S responded by placing each pattern in one of two response categories. In Condition 2S-1R two stimuli were presented on each trial and S was required to indicate which of the two was correct (positive instance). With cue card present the response categories (either one or two) were identified by a sample stimulus card that contained the attribute corresponding to correct assignment of stimuli on the preshift phase of the experiment. Following the shift the cue cards were appropriate for IRD Ss, but were necessarily inappropriate for R Ss since the cue cards could not be changed with the shift. Either size or color was the relevant dimension for half the Ss in all groups. The change in solution for an IRD shift involved a change in the relevant dimension from color to size or from size to color. The R shift simply involved a reversal

of the assignments of the levels on the same relevant dimension.

Each S was told that a series of patterns would be presented and that his task was to discover the proper response to each. Following each response S was told whether or not he had responded correctly. When S made 15 consecutively correct responses the unannounced change in solution was made. Criterion for postshift solution was also 15 consecutively correct responses.

In order to match the conditions of other experiments which have reported R-IRD shift differences, a card sorting task and relatively brief instruction was used. In both respects, the procedure differs from Johnson's study in which Ss were given detailed instructions on how to solve the problem and were required to respond to slides projected on a translucent screen by pressing one or two buttons.

Results and Discussion

Since there was no difference between analyses of variance on errors and trials to criterion, only error data are presented. Analysis of preshift performance showed Dimensions, $F=13.32$, $df=1/96$, and Problem, $F=18.97$, $df=1/96$, $p<.01$, to be the only significant sources of variance. The increase in task difficulty as the number of irrelevant dimensions increased from 2 to 4 has been found in several previous experiments (Bourne & Haygood, 1959; 1960). The Problem effect reflects the greater difficulty of sorting on the basis of size rather than color for the particular stimulus deck used in this experiment.

Figure 1 presents mean errors to criterion in the postshift phase for the R and IRD shifts with cue cards Present and Absent and with 2 and 4 irrelevant

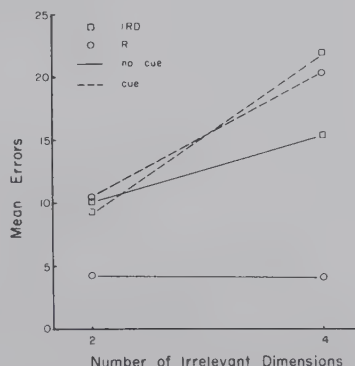


Fig. 1. Mean errors to Criterion on post shift phase for R and IRD shifts with and without cue card over 2 and 4 irrelevant dimensions.

dimensions. An analysis of variance indicated no difference between Problems or among Methods of Presentation. The effect of number of irrelevant Dimensions, however, was highly reliable, $F=11.50$, $df=1/96$, $p < .01$. This effect held for both shift types when cue cards were present, but only for an IRD shift when cards were absent. As a result the overall Shift effect was small, $F=3.81$, $df=1/96$, $p < .10$, while Cue Card condition, $F=10.34$, $df=1/96$, $p < .01$, and the interaction of Cue Card and Shift, $F=4.11$, $df=1/96$, $p < .05$ were statistically significant. Since Ss were required to sort against the cue card in R shift problems an adverse effect was expected. That a similar effect was obtained for the IRD shift with 4 irrelevant dimensions was not anticipated in view of the fact that cue card(s) were consistent with post shift solution.

The primary aim of this experiment was to determine whether either of two procedural variables—availability of cue cards and method of problem presentation—contributed to the failure to find a difference between R and IRD shifts in Johnson's (1965) experiment. The results show a significant R-IRD difference, $F=15.93$, $df=1/50$, $p < .01$, for all three methods of presentation only when no card was present. But cue cards were

not available to Ss in Johnson's experiment. Therefore, while it is interesting and important to note that the availability of cue cards may reduce or eliminate differences in shift difficulty, other factors must have contributed to the atypical results in Johnson's study. Amount of preshift training, instructions, and task format are left as possible variables to be investigated.

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Note

1. This research was undertaken in the Behavior Research Laboratory, Institute of Behavioral Science, University of Colorado and is Publication 61 of the Institute. The work was supported by Grant MH 08315 from the National Institute of Mental Health, U. S. Public Health Service and by Grant GB 3404 from the National Science Foundation.

Differential payoff-loss in probability-learning and decision-making

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Payoffs were differentially manipulated in a modified factorial arrangement to determine the effects on the probability-learning (PL) of two independent events and a subsequent decision-making (DM) task based on the PL. Results were consistent with previous studies using an "absolute" method of incentive distribution. However, differentially weighting the low-probability event appeared to effect early learning and subsequent decision behavior.

Incentive magnitude has been shown to have different effects on learning depending on whether an "absolute" method (where S receives a single incentive level) or a "differential" method (where S receives more than one incentive level) is used. Experiments on both animals (Pobols, 1960) and humans (Lipkin et al, 1965; Myers et al, 1963; and Schnorr et al, 1965) show magnitude of incentive to have no effect on time-independent measures of learning when an "absolute" method is used, whereas incentive effects have been shown in experiments using a "differential" method.

In the Lipkin and Schnorr studies the within-Ss treatment ("differential" method) was a probability-learning (PL) task in which the events to be predicted were worth either 10 cents or 1 cent randomly arranged and both pay-off levels occurred with each event, $\pi_1 = .60$ and $\pi_2 = .40$, equally often. In contrast, the present study was an "absolute" design in which the consistent effects of differentially paying-off two independent events with different probabilities were investigated in a modified factorial arrangement. Further, the effects of these differential pay-offs were examined in a subsequent decision-making (DM) situation in which knowledge of results was not given.

Method

The display panel consisted of two green lights arranged horizontally about 8-1/2 in. apart with a single red light about 2-1/2 in. between and below them. The occurrence or nonoccurrence of each light was controlled using Western Union Tape Programmers.

In the PL part of the experiment Ss saw one of two green lights come on for 5-1/2 sec. and, if it were to occur on that trial, a red light which occurred during the last 3 sec. of the green light. One of the green lights was programmed to be followed randomly by the red event light on 80% of the trials on which it occurred; the other was followed randomly on 20% of the trials. The left-right positions of the green lights were randomly selected by sessions. There were 300 training trials, 150 on each green light with an intertrial interval of 2 sec.

In the DM phase of the experiment the red light was covered to prevent feedback. Ss were then given 30 mixed trials, 10 on each of the green lights separately (as in PL) and 10 with the two green lights occurring simultaneously.

There were six experimental treatments: (1) Penny-Penny (P-P), in which Ss won a penny each time they were correct and lost a penny each time they were incorrect in predicting the occurrence or nonoccurrence of the event light; (2) Nickel-Nickel (N-N), in which Ss won or lost nickels instead of pennies; (3) Penny-Nickel (P-N), in which Ss won or lost a penny on the 80% predictor light and won or lost a nickel on the 20% light; (4) Nickel-Penny (N-P), in which Ss won or lost a nickel on the 80% light and a penny on the 20% light; (5) No Pay-off, in which Ss were simply told to "try to be correct as often as possible", and (6) Utility of Variability (U of V), in which Ss manipulated red plastic discs (having no monetary value) in the same way coins were manipulated in treatments 1 through 4. Treatment (6) was a control for the assumed maximizing effect of the "kinesthetic enrichment" (Siegel et al, 1964) of the manipulation of the coins, while treatment (5) was a control for value to measure the effect of the increased pay-off treatments.

Ss, who were 74 male introductory psychology students at The Pennsylvania State University, were non-systematically selected by experimental session to receive one of the 6 treatments, and were run in groups of 2 to 6 at a time (except for 1 S) in a total of 19 sessions with the same E for all sessions. Four treatments had 12 Ss; the other 2, 13.

All responses were made by pushing a yes or no button on an individual response box and were recorded and summed remotely by a small computer. Ss were to predict whether the red light would follow whichever green light occurred. During PL if S were correct, he took an appropriate coin from the bank and placed it in his cash box. If S were incorrect, he transferred a coin from his cash box to the bank. Ss were told that they could keep all winnings over and above the original stake.

Results

1. There were no consistent differences among the pay-off groups (1 through 4) in final level of responding to either event light in the PL or DM phases of the experiment.

2. There were no real differences between the No Pay-off and the U of V groups either in learning the probabilities of the 2 lights or in the DM phase (when

the red event light was covered). However, in all comparisons the differences were in the direction predicted by Siegel et al.

3. Greater maximization—that is, lower group per cent yes responses—occurred in the pay-off groups than in the no-pay-off groups in PL on the 20% light ($p < .005$, $t = 2.982$, $df = 72$, 1-tailed, after significant F in anova), but there was no overall difference among groups on the 80% light ($p > .10$, $F < 1.00$, $df = 5/68$).

The general negative results in PL in these between-treatment comparisons are consistent with the findings reported in the introduction despite the differential pay-offs of the events within treatments.

4. When both predictor lights occurred simultaneously in DM, requiring Ss to combine in some way the probabilities they learned to associate with each light individually, there were no statistically reliable differences in numbers of yes responses between pay-off and no-pay-off (Figure 1).

Discussion

A possible interesting departure from the overwhelming "no differences" results occurred in a comparison of the P-N and N-P treatments' early learning. If this two-light PL situation is considered as a discrimination task, subtracting per cent yes responses on the 20% light from per cent yes response on the 80% light for successive blocks gives acquisition curves of discrimination between the two lights. Figure 2 suggests that differential monetary weighting of high- and low-probability predictors has its effect mainly on the rate of discriminating between these predictors and not on the final level of responding. Emphasizing the 20% light, as in the P-N treatment,

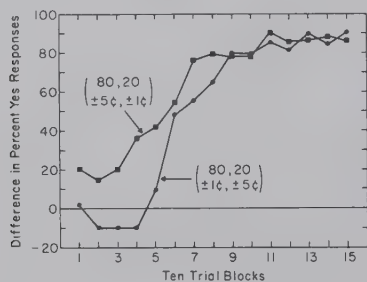


Fig. 2. Differences in learning to discriminate between $\pi_1 = .80$ and $\pi_2 = .20$ in penny-nickel and nickel-penny treatments.

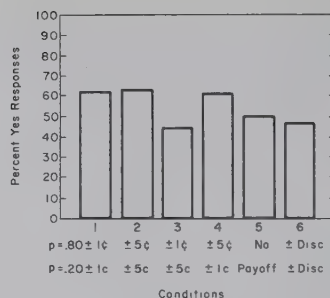


Fig. 1. Percentages of yes responses for the .80-.20 pattern in decision-making.

depresses the discrimination initially so that Ss respond with more yes responses to the 20% light than to the 80% light. Emphasizing the 80% light, as in the N-P treatment, appears to enhance early discrimination. The main difference in learning rate is for the 80% light and disappears after approximately 80 trials.

Finally, it is interesting that the P-N treatment, whose early acquisition rate on the 80% light is retarded in comparison to the N-P treatment, responded with fewer yes responses to the 80-20 combination (see Figure 1) in the DM phase ($p < .05$, $t = 1.863$, $df = 23$, 1-tailed). It appears that weighting the low-probability light in PL has a depressing effect on the subsequent DM. An explanation of this relationship between the retarded early PL and the depressed DM behavior of the P-N treatment is not, however, immediately obvious.

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Note

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Conjugate reinforcement of operant responding in infants¹

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Two studies are reported in which visual conjugate reinforcement induced operant behavior in infants. Responses diminished and increased appropriately when reinforcement was withdrawn and reintroduced. Conjugate reinforcement, involving direct control of reward intensity by S's behavior rate, has promise in the study of infant learning processes.

In learning studies with infants, as with other organisms, various environmental events are sought which promote and sustain some measured behavior. Since extreme conditions of appetite or punishment are rarely used in human studies, such research often capitalizes on the effectiveness of sensory stimulation per se and of social reinforcers. The importance of such reinforcers for human functioning has been dealt with under headings such as "competency striving" (White, 1959), "curiosity motivation" (Butler, 1953), or "manipulation drive" (Harlow, Harlow, & Meyer, 1950), and Ss are said to have need for sensory input and opportunity to experience "recognitive familiarity" (Hunt, 1965). However, in studies involving sensory input as reinforcement rather than more vital consequences of response, reinforcers often lose their effectiveness, due to adaptation or boredom, before the associative process has been demonstrated or explored in depth (Lipsitt, 1963). Thus many infant operant studies are of short duration and few have been sustained for a sufficient period to enable extensive parametric investigations.

Recently, Lindsley and co-workers (Lindsley, Hobika, and Etsten, 1961; Lindsley, 1962, 1963) investigated a type of reinforcement that shows promise in infant conditioning work. *Conjugate reinforcement* involves the presentation of a continuously available event contingent upon response, such that the event's intensity varies directly and immediately with response rate. The prototype is the hand-generator flashlight in which illumination intensity is controlled directly by the response rate and pressure on a trigger or dynamometer handle. Relative to episodic schedules of reinforcement provided by delivery of pellets or candies, or of punitive circumstances with definitive onsets and offsets, the conjugate type of response-consequent permits (1) closer analysis of periodic changes in the value of reinforcing stimuli, and (2) maintenance of the S in the situation for longer periods.

This report describes two studies involving a visual conjugate reinforcing device with year-old children. The rapidity with which some Ss acquired operant behavior under the control of this reinforcer, and the

readiness with which Ss extinguished when reinforcement was withdrawn, suggest that such procedures should be explored at earlier age levels and for longer periods than those in this preliminary work.

Apparatus and Method

In all, 44 Ss within one week of 12 months old were introduced to the conjugate reinforcement situation, 22 under Procedure I and 22 under Procedure II. Of the first 22 Ss, 10 Ss met all criteria for retention and are here reported as a group. In Procedure II, 15 Ss completed the procedures.

The Ss were seated in an infant chair attached to the apparatus containing the operant manipulandum, a clear plastic panel measuring 8 by 9 in. mounted on a box (18 by 18 by 12 in.). Response to the manipulandum activated a special power supply, designed to vary the light intensity in the viewing box through changes in response rate, and consisting of a pulse-averaging circuit and a 110-V, phase-controlled power unit. The response consequent was activation of a 120-watt light source, and S could view whatever stimulus had been placed in the otherwise dark box. Reinforcement, or opportunity to see, was proportionate to the S's response rate, and transition from low to high brightness (and vice versa) occurred gradually rather than in step-wise fashion. No control was attempted over non-linearity between rate and brightness, but apparatus adjustments made possible the selection of the rate required to maintain full brightness. In the present study, when the reinforcer was connected (during conditioning), 2-3 responses per second produced and maintained full brightness. In the viewing box a colorful clown picture was mounted on a 4-in diameter disc, 2.5 in. behind the manipulandum, rotating continuously at a rate of 30 rpm. The room was lighted by a shielded 25-watt lamp in front of the box, out of S's reach and direct view.

Cumulative response records were obtained by the reading of an electrical counter in an adjoining room every 15 sec. In Procedure I, a session consisted of a 15-sec. Baseline period, followed by 5 min. Conditioning (conjugate reinforcer operative), a 1 min. Extinction (reinforcer inoperative), then 2 min. Reconditioning, and 1 min. Re-extinction periods. In Procedure II, Baseline was variable in duration but constant in number of responses required, lasting as long as necessary to obtain five responses, with Ss being dropped from study if five were not obtained within 3 min. In Procedure II, Baseline was followed by 5 min. of Conditioning, two of Extinction, two of Reconditioning, and one of Re-extinction.

The mother put the S in the chair and sat in a chair on S's right. She was asked not to speak unless S cried, in which case she could comfort him in any way she wished. The E entered the adjoining recording room behind a one-way mirror.

Results

Figure 1 shows the average cumulative responses for 10 Ss finishing Procedure I. Five of the initial 22 Ss were eliminated because of crying, three because of interference by mother, one because of procedural error, and three for failing to make any panel responses in the first 3 min. of Conditioning.

To test the effects of reinforcement and its withdrawal, related t-tests compared rate measures in different experimental periods. The difference between Baseline rate and the rate reached in the 5th min. of Conditioning was reliable ($t = 8.00$, $df = 9$, $p < .001$). The rate for every S increased from Baseline to this period. A comparable

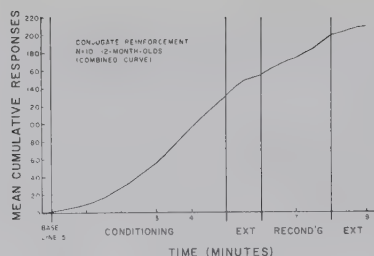


Fig. 1. Combined cumulative record for N-10 under Procedure I.

test was run between the 1st-min. and 5th-min. rates; this difference was reliable ($t=2.70$, $df=9$, $p<.05$), with 9 of 10 Ss showing a rate increase from the 1st to 5th min. Reduction in response rate from the 5th min. of Conditioning to the 1st Extinction min. was not reliable ($t=1.32$, $df=9$) although 6 out of 10 Ss did show a rate decline. Although a group increase in responding occurred between the first Extinction period and Reconditioning, this effect was not reliable. However, following Reconditioning, Re-extinction produced another drop in responding ($t=3.99$, $p<.001$) with no Ss showing an increase in responding.

In succeeding work, it was decided to extend Extinction from 1 to 2 min., and change Baseline from a constant 15 sec. to a variable period, the time required for five responses. Thus, each S began the 1st min. of Conditioning as soon as five non-reinforced responses to the panel occurred. No Ss were retained who failed to emit five responses in 3 min. or who cried prior to making these responses. Of 22 remaining Ss, 15 constitute the Procedure II group, one being eliminated because of mother interference, one because of procedural error, and five because of crying during Conditioning.

Baseline performance was converted to a rate measure: If Ss took 12 sec. in which to make 5 responses, the rate was 25/min. Figure 2 shows the group performance. Rate increased from early Conditioning to late,

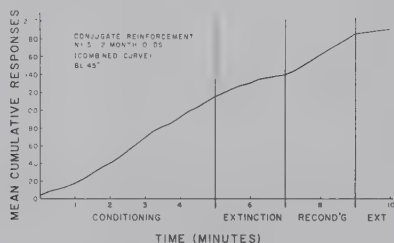


Fig. 2. Combined cumulative record for N-15 under Procedure II.

decreased when reinforcement was withdrawn, increased when reinforcement was reinstated, and decreased again under the second Extinction condition. These propositions were tested with t -tests. From Baseline to the 5th min. of Conditioning, response rate increased significantly ($t=2.22$, $df=14$, $p<.05$). The difference between Baseline and the full 1st-min. Conditioning rate was reliable ($t=5.15$, $df=14$, $p<.01$). Although the rate difference between the 1st and 5th min. of Conditioning missed significance ($t=1.45$, $df=14$), that between the 1st and 4th min. was reliable ($t=3.00$, $df=14$, $p<.01$).

Rate declined from the 5th Conditioning min. to the 2nd Extinction min. ($t=2.32$, $df=14$, $p<.05$). Similarly the rise in rate in reverting to reinforcement was reliable at the .05 level ($t=2.47$, $df=14$). Again, when Extinction was reinstated, behavior rate dropped significantly (2nd Reconditioning min. vs. Re-extinction, $t=3.32$, $p<.01$).

The setting in which the present data were collected made S available for only about 15 min. each, and there was little or no time for the usual shaping-up process that is brought to bear on a recalcitrant experimental subject. Consequently, the number of drop-outs was rather large. For those Ss remaining through the entire procedure, however, it is noteworthy how effective the conjugate reinforcement seems to be. Ss who fail to meet one or the other criterion for retention may reflect true individual differences, themselves of predictive significance. Further studies should explore variations of the present preliminary techniques, using other visual reinforcers in motion and experimental periods of greater duration.

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Note

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Effects of procedural variables upon reversal and interdimensional shift performance: II¹

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College Ss were found to accomplish a reversal (R) shift faster than an interdimensional (IRD) only when simple preliminary instructions were used. The results suggest that with sufficient information Ss adopt a hypothesis-testing strategy, (in concept identification problem) similar to that described by Restle's model (1962).

Contrary to typical results (Kendler & Kendler, 1962), Johnson (1965) found no difference in difficulty between R and IRD shift in the solution of a simple concept identification (CI) problem. An examination of procedures used in various experiments suggested certain factors which might possibly affect the relative difficulty of R and IRD shifts. A subsequent study (Johnson et al, 1965), designed to assess two of these variables—method of stimulus presentation and presence of cue cards—failed to explicate the discrepant findings. Still another difference between Johnson's experiment and some studies of solution shifts lies in the nature of instructions. Whereas in most experiments directions to S were brief and vague, Johnson provided detailed information on the nature of the problem and its solution. These instructions may have induced a hypothesis-testing type of approach to the task. If Ss did select, test and reject alternative possible solutions—particularly in a manner suggested by recent hypothesis models of concept identification (Restle, 1962)—no performance difference between shifts would be expected. These models assume that Ss start over, i.e., resample at random from the complete population of hypotheses, with every error trial. It follows therefore that any shift in problem solution that results in an error trial will lead to the same number of errors in postshift performance. The present experiment investigated the effect of instructions on R-IRD differences, predicting the usual difference with simple instructions and no difference with detailed instructions.

Method

The Ss (48 undergraduates) were randomly assigned to the following conditions of a 2^4 factorial design: Shift—R or IRD; Dimensions—2 or 4 irrelevant; Problem—number or form dimension relevant; and instructions—simple or detailed. In the simple instruction condition, S was merely told that a series of patterns would appear on a screen before him and it was his task to respond by indicating the correct one of two categories for each pattern. Following each response S was told by E whether he had responded correctly. In the detailed instruction condition, Ss were also provided with a list of five possible di-

mensions and told that the solution to the problem involved one of them. The E then showed S a sample solution, e.g., if size was the relevant dimension then all large patterns would go into one category and all small patterns would be assigned to the other category. In addition to the instruction variable this experiment differed from the previous experiment (Johnson et al, 1965) in two respects. Ten instead of 15 trials constituted criterion for both phases of the experiment and the stimuli were slides projected upon a translucent screen instead of cards presented directly to S. In these respects it is similar to the Johnson (1965) experiment which found no R-IRD difference.

Results and Discussion

Since separate analyses on errors and trials to criterion on pre- and postshift performance showed essentially the same results only the error data are presented. The analysis of variance on the pre-shift data showed none of the main effects or interactions to be reliable.

Analysis of variance on the postshift data showed dimensions, $F=13.83$, $df=1/32$, $p<.01$, Shift, $F=6.45$, $df=1/32$, $p<.05$, and Problem, $F=6.20$, $df=1/32$, $p<.05$, all to be significant factors. The Dimension effect was the result of the usual increase in task difficulty with increased number of irrelevant dimensions. The significance of Problems resulted from the greater difficulty of number as opposed to form as a basis for sorting stimuli. The Shift effect can be seen in Fig. 1, which shows mean errors to criterion for R and IRD shifts with simple and detailed instructions combined over dimensions and problems. From Fig. 1 it can be seen that the IRD shift is generally more difficult, but that shift difficulty interacts with the type of instructions given. The analysis of variance

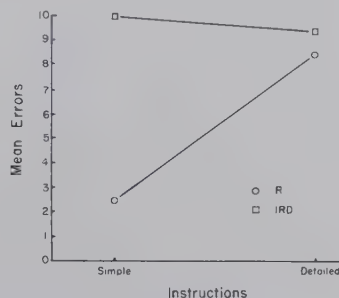


Fig. 1. Mean errors to criterion on postshift phase for R and IRD shifts on Simple and Detailed instruction conditions.

showed the Shift by Instruction interaction to be only marginally significant, $F=3.42$, $df=1/32$, $p<.10$. Such an analysis, however, does not provide an explicit test of the hypothesis that there is no R-IRD difference under the detailed instruction condition, but a significant difference under the simple instruction condition. Planned pairwise comparisons showed no reliable difference between R and IRD shifts for the detailed instructional condition, $F=.20$, $df=1/32$, while the R shift was significantly less difficult, $F=9.85$, $df=1/32$, $p<2.01$, for the simple instructional condition.

These results suggest that the added information given Ss with detailed instructions was responsible for the disappearance of any R-IRD difference in Johnson's (1965) experiment. Instructions which include explicit labels for the stimulus dimensions, which indicate that only one dimension will be relevant, and which demonstrate a possible solution to such a problem, all probably combine to induce a hypothesis-testing type of responding. Under these circumstances the expecta-

tion of no difference between R and IRD shifts based on a literal interpretation of hypothesis testing theories (Restle, 1962) is realized.

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Note

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The measurement of "adopted chunks" in free recall learning¹

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Ss were given one learning trial on each of three lists presented in counterbalanced order. One of the lists contained items of the first order of approximation to English; another contained third order items; and the third consisted of text order items. After each trial Ss recalled as many items or parts of items as they could. The number of whole items remembered was a direct function of approximation to English. When "adopted chunks" were measured, there were no differences among lists in the number of chunks remembered. Between seven and eight chunks of information were recalled at all orders of approximation.

In most verbal learning studies, what Ss learn is usually expressed in terms of the number of "whole" items that they get correct. For the experimenter, it may be simple to measure whole items, but to imply that people learn verbal material only in terms of complete words, or complete nonsense syllables, or complete items of any kind is undoubtedly erroneous. There is probably some material that Ss learn in units the size of a word; but there is probably other material that Ss learn in units the size of two, three, or four words; and there is probably yet other material that Ss learn in units much smaller than whole items, the size of these units being perhaps only two or three letters. Related to the notion of a "subjective" response unit is Miller's (1956) concept of the "chunk." He believes that people tend to master verbal material in chunks of information organized as units. The number of these units that a person is able to receive, process, and remember, irrespective of the amount of information per unit, appears to be a constant and is limited to about seven, plus or minus two, chunks of information.

The major problem is how to measure these subjective units. Tulving & Patkau (1962) assume that S adopts some sequential organization from the input list. Thus, their "adopted chunk" is defined as any group of one or more items which occurs in S's recall in the same sequence as in the input list. They found that their Ss remembered approximately the same number of adopted chunks under all experimental conditions. While they were interested in how groups of words were formed into chunks, the aim of the present study was to determine whether Tulving and Patkau's method could be used to measure how groups of letters within words or items, as well as groups of items themselves, are organized into chunks. An adopted chunk was therefore re-defined as any group of one or more letters which occurred in S's recall in the same order

as in the original input list. Defining it in this way meant that chunks smaller in size than whole items would be measured, and yet two or more whole items which occurred in the same order in S's recall as in the input list would still be counted as only one chunk. An additional restriction was placed on one-letter "chunks" to eliminate the possibility of Ss' simply guessing single letters at random. To be counted as a chunk, a single letter had to be recorded in its correct intra-item serial position.

Method

Ss were 18 women taking an introductory course in psychology. Sixteen eight-letter sequences at each of the first, third, and text orders of approximation to English from another study (McNulty, 1965) were used as learning lists. Each S was given all three 16-item lists to learn. The order of presentation of the lists was counterbalanced over Ss, three Ss learning each of the six possible orders of presentation.

Only one learning trial was given on each list, with the 16 items being presented on a memory drum at the rate of 3 sec. per item. Three random orders of each list were constructed, with the three Ss in each of the six order of presentation groups learning different random orders of any list. After the learning trial on each list, S's task was to write down, in spaces provided on the record sheet, as many items as she could remember. Even if S could not remember an item in its entirety, she was instructed to write down as many letters in their correct positions in the item as she could. (The spaces for each item on the record sheet contained eight blanks, one for each of the eight letters in the item) Exactly 2 min. was allowed for recording responses, and, after a further 3 min. break during which S rested, the next list was presented. Detailed instructions regarding the task were given before the first learning trial was begun.

Results and Discussion

The mean number of whole items correctly recalled at each order of approximation is shown in Fig. 1. As one would expect, recall increased with approximation to English and this effect was highly significant statistically. An analysis of variance revealed no other significant effects. For example, the order in which the learning lists were presented had no effect upon recall scores.

Figure 1 also shows the mean number of adopted chunks recalled at each order of approximation. No significant differences due to approximation to English or any other variable were found in the number of

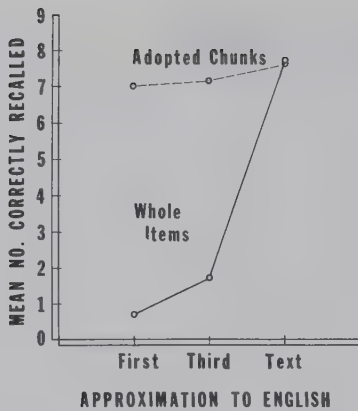


Fig. 1. Mean numbers of whole items and adopted chunks correctly recalled at each order of approximation to English.

chunks that were remembered. The number of chunks recalled appeared to be relatively invariant from one order of approximation to the next. It is interesting to note how closely the mean number of chunks at each order of approximation agrees with Miller's (1956) "magical number seven." At text order the number of chunks and words correctly recalled is about the same, indicating that after a single exposure of unrelated text order items a chunk of information corresponds roughly to a single word.

The size of an adopted chunk (in number of letters) did, of course, vary as a direct function of approximation to English. The fact that chunks vary in size should be no more surprising than the fact that words vary in size. Chunks are probably equivalent units of information to Ss and just as basic and unitary as words.

Undoubtedly, some "chance" chunking occurs. Data for "statistical" Ss were therefore generated. All of the letters comprising the items in a particular list were put into a box and letters were drawn at random to match the performance (in number of letters) of

actual Ss. The important consideration was not whether statistical Ss could "recall" as many chunks as actual Ss. Rather, the important point was whether or not chunks of the size of those observed in the recall of actual Ss could have been obtained by chance without their having been remembered from the input list. Thus, a statistical S was credited with a chunk only if it was at least as large in size as a chunk in the recall of the actual S. Amount of chance chunking was found to be negligible at all orders of approximation. In addition, the estimates are still probably too large because they did not take into account the facts that (1) Ss wrote down very few sequences of letters which were not in the input list while statistical Ss made a great many more "errors" than "correct" responses, and (2) nearly all of the chunks that actual Ss recalled were written down in the spaces on the record sheet corresponding to their actual positions in the learning items. (Details on how chance chunking was estimated may be obtained from the author upon request.)

With additional learning trials, the size of the chunks at each order of approximation would be expected to increase as Ss organize and learn the material. Nevertheless, the number of chunks correctly recalled on any trial should not change. At present, there is really no way to measure the number of chunks in later trials, although Tulving (1962) has developed a method to measure the organization that Ss impose upon unorganized material.

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Note

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Short-term recall of paired-associates as a function of the number of interpolated pairs¹

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A continuous technique for studying short-term memory of paired-associates was used. For 4, 6, or 8 stimuli, recall was found to be a decreasing function of the number of pairs of items interpolated between study and test on a given item. Reliable differences between the functions for 4, 6, and 8 stimuli were found.

In a typical paired-associates paradigm for the study of short-term memory, a list of items is presented and the S is then required to give the correct response to one of the stimuli selected from the list (e.g., Murdock, 1963). Since only one of the pairs is tested on a given presentation of the entire list, it is difficult to gather large amounts of data under homogeneous conditions. This paper introduces a modification of this short-term memory procedure that provides for the efficient gathering of large amounts of data under fairly homogeneous conditions. The technique is similar to one used by Yntema & Mueser (1962), and permits us to collect two to three thousand comparable observations from a S in 10 1-hr. sessions.

METHOD

Subjects. The Ss were 10 students from Stanford University who received \$2 an hour. Each S participated in at least 10 1-hr. experimental sessions.

Apparatus. All programming, generation of stimuli, and response recording were carried out with an on-line PDP-1 computer. Stimuli were electronically generated and displayed on the face of a cathode ray tube (CRT). Responses were made on an electric typewriter keyboard located immediately below the lower edge of the CRT.

Stimuli and Responses. The stimuli were two-digit numbers randomly selected for each session from a set of all two-digit numbers between 00 and 99. Once a set of stimuli was selected for a given session, it was used throughout that session. In each session the same six responses were used: the letters F, G, H, J, K, and L.

Procedure. For each session each S was assigned to one of three experimental conditions. The conditions (labeled 4, 6, or 8) indicate the number of stimuli that were used in a given session. An attempt was made to assign Ss to each condition once in each consecutive three-session block. Each session began with a series of consecutive study trials: one study trial for each stimulus to be used in the session. On each study trial the word *study* appeared on the upper face of the CRT. Beneath the word *study* there appeared one of the stimuli to be used in the session along with a randomly-selected

response member. Ss had been initially instructed to try to remember the association between the pairs of items which appeared along with the word *study*. Each of these initial study trials lasted for 3 sec., with a 3-sec. intertrial interval (ITI). As soon as there had been one initial study trial for each stimulus to be used in the session, the session proper began.

Each trial involved a fixed series of events: (1) The word *test* appeared on the upper face of the CRT. Beneath the word *test* there appeared a randomly selected member of the stimulus set. Ss had been instructed that, when the word *test* and a stimulus appeared on the CRT, they were to respond with the last item they had associated with that stimulus. This test portion of each trial lasted for 3 sec. (2) CRT was blacked out for 2 sec. (3) The word *study* appeared on the upper face of the CRT for 3 sec. Below the word *study* a stimulus-response pair appeared. The stimulus was the same that had been used in the preceding test portion of the trial. The response item was randomly selected from the response set, with the stipulation that the response be different from the immediately preceding response item assigned to that stimulus. (4) Three-sec. ITI before the next trial.

RESULTS

Figure 1 presents the proportion of correct responses in 50-trial blocks, for each of the three stimulus conditions. It can be seen that the curves appear

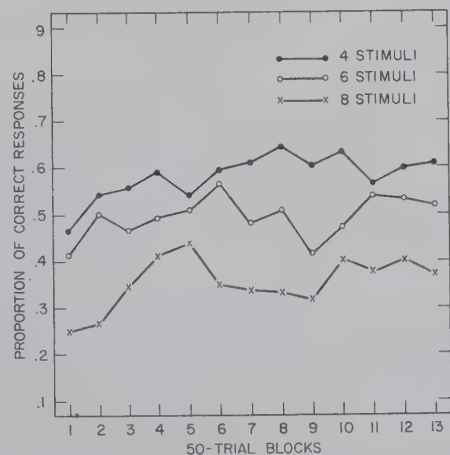


Fig. 1. Proportion of correct responses as a function of trial blocks. Data for each stimulus condition are summed over all subjects and sessions.

to have leveled off at three distinct asymptotes. Due to the warm-up effect, subsequent analyses will not include any of the first-day sessions nor the first 25 trials of subsequent daily sessions. The number of trials intervening between study and test for a given item will be referred to as the lag for that item. Thus, if the test for a given stimulus occurs immediately following the study for that stimulus, the lag is 0. If one trial intervenes, the lag is 1, and so on. Figure 2 presents the proportion of correct responses as a function of lag. In order to determine the reliability of the differences between the three curves in Fig. 2 the proportions correct for each S for each of the conditions were calculated and then ranked. An analysis of variance for correlated means indicated that the curves differed reliably ($F = 7.65$, $df = 2/18$, $p < .01$).

DISCUSSION

For a given lag, the more stimuli used, the more different intervening stimuli there are. For example, with a lag of 3 it is much more likely that the three intervening stimuli are all different when there are eight stimuli than when there are four stimuli. Except for lag 1, it might be the case that the differences in the three curves merely reflect the number of different intervening items for a given lag. In an additional analysis, the curves in Fig. 2 were replotted in such a way that there were no repeated stimuli for a given lag.

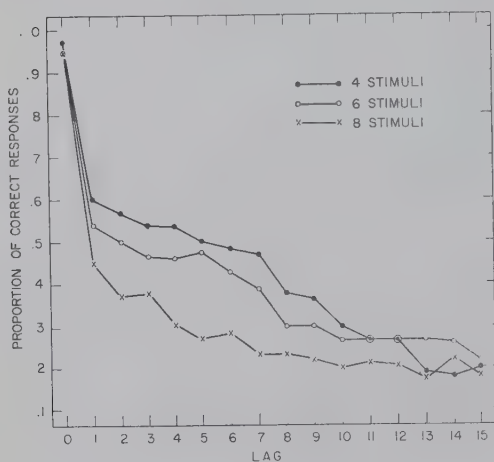


Fig. 2. Proportion of correct responses as a function of the lag between study and test trials. Data for each stimulus condition are summed over all subjects and sessions.

These curves were found to be even more divergent than those in Fig. 2. It thus appears that the differences in the three curves are not simply due to an artifact of the presentation procedure.

In a recent theoretical formulation of short- and long-term memory, Atkinson & Shiffrin (1965) proposed a model that may be applied to the present experiment. The central assumption is that items enter a constant-sized memory buffer knocking out an item from the buffer as they do so. The present results can be explained qualitatively in this framework if it is assumed that an item presented for test, which is currently in the buffer, replaces itself rather than another item. In the conditions with fewer stimuli, items will be replacing themselves more often and forgetting will be slower. This model predicts the qualitative aspects of the data in Fig. 2 such as the divergence and then convergence of the curves to the guessing level. It remains for a more detailed analysis to determine just how well a model of this sort accounts quantitatively for the data.

Some additional remarks should be made regarding the relation of the results in Figs. 1 and 2. It is possible that all three curves in Fig. 2 could be identical, and still generate differences of the type displayed in Fig. 1 among the three groups. That is, the probability of a correct response as a function of lag could be independent of the size of the stimulus set, and still we would obtain differences in the overall rate of correct responding since smaller set sizes would tend to have shorter lags for testing. Thus the major findings in this study are summarized by the functions in Fig. 2.

One final point should be brought out in connection with the present data. By the time 10 or more pairs of items have intervened between the study and test for a given item, Ss are performing at close to chance level. It thus seems that a short-term memory process is the dominant factor in the present experimental situation.

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Note

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Affect and short-term retention¹

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The effects of motivation on retention were investigated. Using a short-term memory technique, stimuli were cued for different incentives. At a short time interval there were no differences in recall as a function of the incentive condition. However, after a longer interval, stimuli associated with a five cent reward or shock were recalled significantly more than stimuli for which neither shock nor money was a potential outcome. It was argued that motivation did not affect the strength of original learning, but did influence the temporally subsequent process of trace storage.

There are a number of major methodological inadequacies in studies relating motivation to memory. Among these shortcomings are a confounding of the degree of original learning with the amount of retention, and a lack of control of the behavior (e.g., rehearsal) between the onset of the to-be-remembered event and the time of recall (see Rapaport, 1942; Weiner, in press). A recent study by Weiner & Walker (in press) has overcome these difficulties by using the short-term memory technique devised by Peterson & Peterson (1959). In the Weiner and Walker study consonant trigrams cued for different incentives were used as stimuli. During the interval prior to recall Ss read digits in time to a metronome. The investigators found that following a short period of interpolated activity there were no significant differences in recall. However, after a longer interpolated interval, stimuli for which recall was rewarded with five cents and stimuli for which nonrecall was punished with shock were recalled significantly more than control stimuli. In the Weiner and Walker study the behavior between stimulus onset and later recall was controlled. Further, since no differences in immediate recall were found, the investigators concluded that motivation affected retention and not original learning.

The Weiner and Walker study is subject to some methodological criticisms. In their study recall at the short time interval was above 80% when responses were dichotomized as correct or incorrect. Underwood (1964) and Keppel (1965) have emphasized that actual differences in learning may be masked when performance is near asymptote and relatively insensitive measures of learning are used. The present investigation attempts to replicate the basic findings of Weiner and Walker, employing two methodological changes to insure that potential differences in learning are not masked. To decrease the overall level of performance four letter consonant stimuli rather than trigrams are the to-be-remembered units. And, to increase the sensitivity of the response indicator, each response is evaluated on an eight point scale of approximation to the correct response.

Procedure and Results

Four letter consonants cued for four different incentives were used as stimuli. The background colors on which the stimuli were flashed provided the discriminative signals. The four incentives were: one cent reward for correctly recalling the stimulus; five cents reward; shock for incorrectly recalling the stimulus; and a control condition. The shock was in the order of 200 volts with an exponentially decaying oscillation function which decreased to near zero in 3 msec. Each stimulus was projected for 1 sec. and read aloud by the S. There were three recall intervals: 2.8 sec., 9.35 sec., and 17 sec. During this interval the Ss read digits in time to a metronome beating 3.2 times per second. The recall period was 12 sec.

Ss first learned the color-incentive pairings. This was followed by six practice and 72 test trials. Within the first and last 36 trials each of 12 conditions (three time intervals by four incentives) appeared three times. The order of presentation was randomized but constant across Ss. The design was counterbalanced so that the color-incentive pairings varied across Ss. Ss were 20 male students.

Responses were scored one point for each consonant recalled and two points for each consonant recalled in its correct position. The maximum score of eight was received for perfect recall. The mean response score for each incentive condition at the three time intervals is shown in Fig. 1. An analysis of variance reveals a significant main effect due to the incentives, $F(3,57) = 8.70$, $p < .01$. A Newman-Keuls paired-mean test reveals that there are no significant differences in recall at the short time interval. At the intermediate interval stimuli associated with shock are retained significantly more than the control stimuli ($p < .05$). At the long interval stimuli associated with shock are recalled significantly more than stimuli associated with a one-cent reward ($p < .05$) and the control stimuli ($p < .01$). Stimuli paired with a five-cent reward also are recalled significantly more than the control stimuli ($p < .05$) at the long time interval.

Discussion

The general pattern of results replicates the findings of Weiner & Walker. Although a more difficult task and a more sensitive response indicator were used in the present study, there were no differences revealed in recall at the short time interval. This strongly suggests that Weiner & Walker had not masked possible learning differences. In a subsequent study this pattern of results again was replicated when the incentive cue was presented just prior to the onset of the stimulus.

There are several possible interpretations of the different rates of forgetting. It might be reasoned that

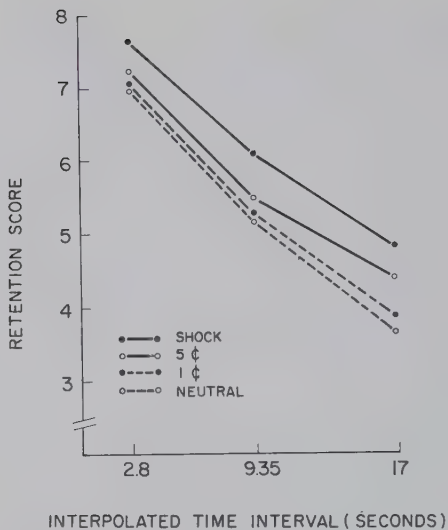


Fig. 1. Mean retention score at three time intervals as a function of the incentive condition.

there was differential rehearsal of the stimuli. However, the speed and difficulty of the interpolated task limits

the feasibility of this explanation. Further, Peterson & Peterson (1959) report that instructions to silently rehearse do not facilitate retention when this procedure is used. Finally, differential rehearsal would not explain the interaction found between the incentive conditions and the time intervals.

The present authors believe that the motivational manipulations in this experiment influenced the subsequent storage of the stimulus. It is suggested that heightened motivation during the perception of an event decreases the likelihood that the trace of that event will be subject to retroactive interference.

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Note

- 1 This study was submitted by Phyllis Kernoff in partial fulfillment of the requirements for the Master's Degree at the University of Minnesota. The research was supported by a grant from the Graduate School of the University of Minnesota and by research grant MH 11416-01 from the National Institute of Mental Health.

Einstellung during simple discrimination learning¹

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Ss were given a simultaneous discrimination problem, in which the larger of two circles was correct, after 0, 3, or 6 problems with position sequence solutions. On all problems Ss were presented with a series of 100 cards, each with two circles of different sizes, and chose one of the circles. The O-condition Ss solved the problem in a mean of 3 trials; the Ss in the other two conditions required a mean of 63 trials, with almost half of the Ss not solving in 100 trials. There was no significant difference between Ss receiving 3 and 6 preliminary problems.

The harmful effects of set, or Einstellung, on problem solving have been demonstrated in a number of studies, the best known of which is probably Luchins' (1942) study with water-jar problems. In the present experiment Einstellung was studied in the context of discrimination learning. The advantages of this procedure are that the stimulus situation is extremely simple, and detailed theories have been formulated which relate discrimination learning to a variety of learning phenomena (Estes, 1959; Restle, 1955).

Method

The Ss were 90 students from introductory experimental psychology classes at Indiana University.

Two decks of 100 cards each were made up, on each of which were two circles of different sizes. For one deck (the "1.3" deck) the larger circle had a radius of 2.5 cm, and the smaller, 1.3 cm. For the other (the "2.0" deck) the radii were 2.5 and 2.0 cm. In each deck, 50 of the cards had the larger circle on the left, and 50 had it on the right. The two kinds of cards alternated randomly except that no more than three cards in a row had the same arrangement.

Each S received either 0, 3, or 6 preliminary position-sequence problems before a final problem in which the larger circle was always correct. There were six groups of 15 Ss each, arranged in a 3 by 2 factorial design (3 numbers of preliminary problems, and 2 types of decks). The Ss getting six preliminary problems received first a 2L-2R (2 lefts followed by 2 rights correct throughout) problem, followed by five problems: 3L-2R, 1L-4R, 5L-1R, 2L-4R, and 3L-3R, presented in a Latin-square arrangement. The Ss getting three preliminary problems received the 2L-2R problem followed by two of the other five problems. These were also counterbalanced.

Each S was run individually. He was instructed at the outset to point to the center of one of the two circles on each card. The E said "right" or "wrong" after each response. The criterion of learning was 15 consecutive correct choices. If the S did not reach criterion after

all 100 trials on a preliminary problem, he was told the solution and went on to the next problem. He was questioned after all the problems had been presented as to the hypotheses he had tried out on each of the problems.

Results

Two measures of performance were obtained—trial of last error (TLE) and total number of errors. Since both yield identical conclusions, only results for TLE will be given.

No significant effects were produced by the two types of decks (1.3 vs. 2.0).

A learning-to-learn effect was found on the preliminary problems. The first problem had a mean TLE of 65, with regular decreases to the sixth position-sequence problem, which had a mean TLE of 16. No significant difference was found between the different position sequences.

On the final problem, performance of Ss given three or six preliminary problems was drastically poorer than that of control Ss given none. Mean TLE's were: for Ss given zero preliminary problems, 3.2 (the slowest S had a TLE of only 11); for Ss given three, 57.5; for Ss given six, 68.3. Twenty-eight of the 60 Ss in the last two conditions failed to reach criterion in 100 trials. The difference between these two conditions was not significant by the Mann-Whitney U test.

The post-experimental interview showed that 95% of the Ss given preliminary problems reported the use of position-sequence hypotheses on the final problem. These were rarely reported by Ss given no preliminary problems.

Discussion

The results indicate that extreme retardation in learning a trivially simple problem was produced by the preliminary task. As is characteristic of the Einstellung effect, the Ss seemed to become "blind" to the critical relationship, here between pointing to the large circle and the E saying "right". This is undoubtedly attributable to the tendency to look for position-sequence solutions induced by the preliminary problems. That the S came to restrict his hypotheses to those concerning position sequences is indicated both by the preliminary problem performance (striking improvement over problems was found) and by the post-experimental reports (such restriction of hypotheses was always reported). It would appear, then, that when the adult human S has a large set of hypotheses, or possible solutions, from which to sample, he can become quite restricted and rigid in his sampling from that set.

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1. Based upon a thesis submitted in partial fulfillment of the requirements for the M.A. degree at Indiana University.
2. Now at the University of Kansas.
3. Formerly at Indiana University.

Comment on "Adaptation of humans to colored split-field glasses" by John C. Hay and Herbert L. Pick, Jr.

Recent studies (Harrington, 1965; McCollough, 1965) have failed to confirm the gaze-contingent after-effects of split-field color spectacles (Kohler, 1964, 1962). McCollough has further shown how Kohler's observations may have been due to artifacts in his test procedure. However, another kind of gaze-contingent after-effect reported by Kohler has been replicated: the gaze-contingent after-effects of prismatic distortions of form (Pick & Hay, 1964; Pick & Hay, in press). It would seem, therefore, that gaze-contingent after-effects do exist, for distortions of form, but that Kohler's conditioning theory of those after-effects is in doubt, since it predicts that similar gaze-contingent after-effects should occur for distortions of color (Kohler, 1964, pp. 16, 26, 123 et seq.).

Why should form perception come under the control of eye position while color perception does not? It seems possible that the influence of eye position on form perception is only a modification of a normally existing relationship between the two. For example, when the head is turned, the eyes turn in a reflex fashion, which normally helps keep a constant image on the fovea. The prism makes this reflex eye movement inadequate for preserving the foveal image, since the prismatic displacement changes with the viewing angle through the head-fixed spectacles. Thus when Swearing base-left prisms moves his head down, horizontal

image lines are tilted counter-clockwise. Adaptation to this distortion could involve a modification of the reflex eye movements, such that they acquire a torsional component partially cancelling the prism-produced image rotation. Recent evidence supports such an explanation: Hay & Pick (in press) found that vertical image lines are affected similarly to horizontal image lines by the adaptation, whereas the prisms differ in their effects on vertical and horizontal lines.

By contrast, the split-field color distortions have no natural relation to eye movements. Eye movements could in no way counter-act the change in image color caused by these spectacles. If gaze-contingent color after-effects developed, it would mean that an entirely novel mechanism had developed, relating the color response of the visual system to eye posture.

In terms of this analysis, the gaze-contingent after-effects which do occur, those to prismatic distortions of form, represent a modification of an already existing relationship, rather than the "conditioning" of a new relationship. This means that they do not support Kohler's theory that "the visual system (is open) to the influence of a wide range of other sensory or sensorimotor conditions, provided only that they are marked enough, and that they regularly coincide with a specific visual stimulus" (Kohler, 1964, p. 16). Instead, the present analysis makes gaze-contingent adaptation comparable in nature to other, gaze-invariant after-effects: adaptation is a change in an existing mechanism due to atypical stimulation of that mechanism.

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The reliability of free association responses

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Free association responses were obtained from high and low frequency stimulus words for 61 Ss. Seven or 21 days later, Ss responded to the same stimulus material. Results indicated that neither word frequency nor interval between sessions influenced the number of identical responses made by the S. Findings indicated that an S will make the same response to the same stimulus word presented on two different occasions, about 50% of the time.

Starting with the general assumption that free association responses may be used as indicators of verbal habit strength, a number of investigators have been interested in how free associative structure influences learning, transfer, and recall (i.e. Russell & Storms, 1955; Deese, 1959; Postman, 1961; Higa, 1963; Martin, 1964; Winegartner, 1964; Wicklund, Palermo, & Jenkins, 1964). Few experimenters, however, have been concerned with the reliability of word association responses. Wells (1911) in an examination of practice effects in free association, obtained some data related to the problem, but the uniqueness of his experimental procedure and small N makes his study difficult from which to draw conclusions.

The present study was an attempt to investigate the reliability of word association responses as a function of: (a) the use of high and low frequency stimulus words, and (b) a 7 or 21 day period intervening between the first and second testing.

Method

The stimulus words consisted of 27 high frequency, six letter adjectives, and 27 low frequency six letter adjectives. High frequency words had a frequency count of 50 or more occurrences per million; low frequency words had a frequency count of 1 to 5 occurrences per million. All words were randomly selected from the Thorndike-Lorge Word Book of 30,000 Words (1944). Stimulus material was presented with a Revere automatic slide projector. Instructions emphasized that the S was to provide the first response which came to mind. Each S was then presented with a few practice words in order to provide familiarity with the procedure. The 54 high and low frequency words were then presented in a random order. At the conclusion of the session, the S was scheduled to return either 7 or 21 days later. During the second session S was run through exactly the same procedure. Instructions acknowledged that the S was participating in a second session but stressed the fact that responses were to be "free."

Sixty-one Ss, obtained from an introductory psychology course, participated, with 31 Ss retested seven days after the first session while 30 Ss were retested after 21 days.

Results and Conclusions

Sixty-one Ss responding to 54 words on each of two sessions provides 3294 test-retest responses. Of these, 132 were lost when the S blocked to the stimulus word when it was presented on one of the two sessions. Thus, 3162 responses make up the basic data.

A primary concern was to examine the number of responses made during the second session which were identical to those provided on the first. In making the identity of response classification, a response which was plural in form was considered to be identical to the singular. The mean number of identical responses for the varying conditions is presented in Table 1. Analysis of variance revealed that neither word frequency, interval between sessions, nor their interaction produced a significant effect. Summing over all groups, slightly less than 50% of the time, an S's response to a stimulus word will be the same on the second testing as that provided on the first.

An ad hoc analysis of the data was made in order to determine if those stimulus words which resulted in many Ss responding similarly on the first session would maximize identity of individual responding during the second session. To illustrate, 32 Ss (of 61) made the response GOLD to the stimulus word SILVER; on the other hand, to the word SECRET, the most frequent response was QUIET which had an N of 5. It might be assumed that many more identical responses would be made to SILVER than to SECRET—an assumption, of course, which rests on the frequently held position that group responding reflects individual habit strength. In order to test this assumption, a product moment correlation was computed between the number of common responses obtained from each of the stimulus words during the original testing, and the number of identical responses which were made to those words during the second session. The obtained r was .01, which suggests that this variable also does not covary with identity of responding.

A second area of concern was related to the nature of the nonidentical responses. Here, interest was directed in examining whether or not these nonidentical responses could be found in the original response hierarchy. Hierarchies were compiled, based upon the responses made by the 61 Ss during the first testing.

Table 1. Mean Number of Identical Responses Made as a Function of Word Frequency and Time Between Testing

	N	Low Frequency	High Frequency
7 Days	31	12.35	13.48
21 Days	30	11.57	11.60

Table 2. Mean Number of Nonidentical Responses Found Within the Original Response Hierarchy

	N	Low Frequency	High Frequency
7 Days	31	6.13	6.90
21 Days	30	7.07	8.37

Each nonidentical response made during the second testing was then classified as to whether or not it fell within the hierarchy—that is, whether or not it was the same as one of the words comprising the original response hierarchy list. Tables 2 and 3 provide this information, broken down into high and low frequency words and interval between sessions. Again, differences among groups were not significant.

Summing over groups, a little more than 27% of the responses made on the second testing fall within the response hierarchy, while approximately 25% fall outside the hierarchy. It should be noted that these percentage values are dependent upon the number of Ss which make up the sample. As sample size increases, a larger number of words will comprise the response hierarchy, thus increasing the probability that more

nonidentical responses will be found within the response hierarchy rather than without.

Our findings indicate, then, that in the free association situation an S will make the same response to the same stimulus word presented on two different occasions, about 50% of the time. This value presumably provides sufficient stability to enable investigators to utilize word association responses in their experimental analysis of learning, transfer, and retention. Such identity of responding does not appear to be influenced by either the use of high or low frequency stimulus words, or by the interval of time (up to three weeks) between sessions.

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Table 3. Mean Number of Nonidentical Responses which were Found Outside the Original Response Hierarchy

	N	Low Frequency	High Frequency
7 Days	31	6.45	5.97
21 Days	30	7.20	6.57

Duration of looking and number of brief looks as dependent variables¹

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The duration for which human Ss exposed themselves to stimuli before responding on simultaneous discrimination problems varied with stimulus difficulty, discrimination reversal and reinforcement schedule.

In many situations in which S's task is to make a discrimination, no knowledge of the course of learning can be obtained since only success or failure can be recorded. The hypothesis that some intensive property of "looking" can provide an index of the time-course of the formation of a discrimination is examined in the present experiment.

Once S looks on every trial, the standard digital measure of the observing response (e.g., Skinner, 1953; Wyckoff, 1952) precludes detecting further variation in looking. However, it seems certain that the frequency of looking at a stimulus of short duration or the duration of a look at a stimulus of subject-controlled duration will vary as a function of the parameters of discrimination.

Method

Human Ss, obtained from introductory psychology, were instructed in the use of a stimulus control button and tested on simultaneous discrimination problems. The S was seated before a screen on which the stimuli were projected and was provided with three keys. The center key presented the stimuli and the two side keys registered the choice. Lights above the side keys indicated correct choices. Two procedures were used. In the first, operation of the center (stimulus) key presented the stimuli for 0.2 sec., and S was allowed an unlimited number of these exposures per discrimination trial. Frequency per trial was recorded. In the second procedure, the stimulus key exposed the stimuli for the duration of the key depression. Durations were recorded. The stimulus material consisted of sets of 10 by 10 grids with varying degrees of randomly-selected fill.

Results

The effect of stimulus difficulty was explored by two problems in both of which the two grids were 50% filled but with an 85% overlap of the grids in the "hard" problem and only a 15% overlap in the "easy" problem. Both problems were presented to the same six Ss, "hard"-"easy" for three Ss, "easy"-"hard" for the other three, and with the second problem given immediately after the first.

Figure 1 shows duration of stimulus exposure as a function of blocks of successive five trials, with separate curves for the two problems. Both the effects of problems and trials were significant ($p < .01$), though

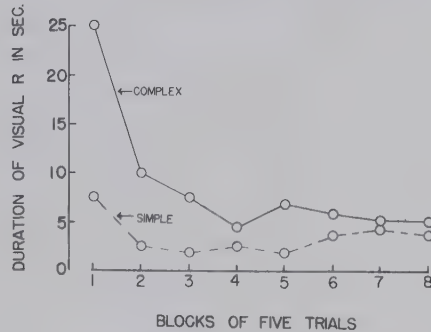


Fig. 1. Effect of stimulus complexity on looking time

the P by T interaction did not attain the 5% level. Initial looking times clearly differed in the expected direction but the more interesting question of asymptotic difference will require further tests.

Both curves in Fig. 1 show a gradual decline in looking time over trials. These data are not wholly representative of individual performance where, more typically, a long early look—not necessarily on the first trial—was followed by a nearly asymptotic decline. Figure 2 shows six representative records for experienced Ss, three for duration procedure, three for number procedure. The problems were of the same grid type. The naive human S often produces a later stimulus exposure equal to or even longer than an earlier one, but such performance is rare in the experienced S.

The effect of discrimination reversal was studied with 24 Ss who were given a reversal on trial 21 following 20 standard discrimination trials. As shown in Fig. 3, which plots exposure time and choice responses averaged over all Ss per block of five trials, the reversal occasioned a clearcut increase in both exposure time and discrimination errors. Interestingly, the looking duration produced by the reversal did not equal that found at the beginning of the problem. Both errors and looking time increased together; this relation was examined in the next experiment by manipulating reinforcement schedule.

Three groups of six Ss each were given the same discrimination problem in conjunction with a different reinforcement schedule. The schedules were: one stimulus always correct, the other always incorrect (differential reinforcement); both stimuli always correct (nondifferential reinforcement); both stimuli correct 50% of the time at random with neither correct more than twice in a row (random reinforcement).

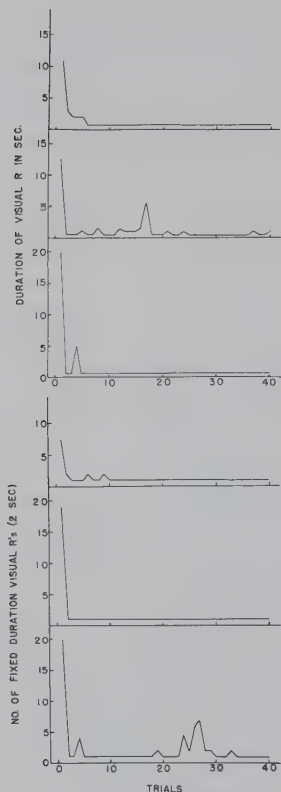


Fig. 2. Representative individual records

Figure 4 shows duration of looking as a function of blocks of five trials with separate curves for the three reinforcement groups. Looking time was least for the group that was nondifferentially reinforced, intermediate for the standard differential condition, and greatest for the random condition. Interestingly, exposure time decreased over trials for the random condition as well as for the other conditions. The main effects of groups and trials were both significant ($p < .01$), while the G by T interaction did not reach the 5% level. *t*-tests showed all groups except the differential and nondifferential to differ by at least the 5% level.

Conclusions

These results, indeed, show that two intensive properties of looking are sensitive to such variables as

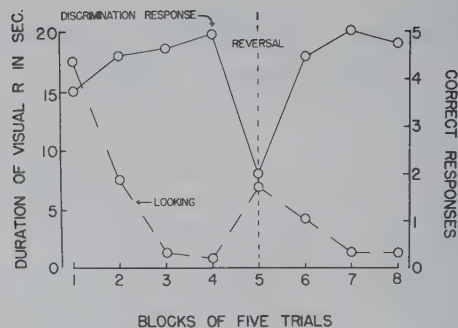


Fig. 3. Effect of discrimination reversal on looking time and instrumental choice

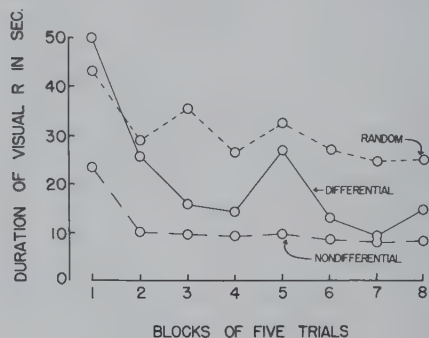


Fig. 4. Effect of reinforcement schedule on looking time

practice, difficulty, and reinforcement, commonly used in discrimination studies. The large difference between initial looking durations and those observed at the time of the reversals in the discrimination reversal problem suggest that perhaps a two stage problem is involved in looking. The first is familiarization with the range of stimuli involved, the second is the solution of the problem, the latter requiring briefer or fewer looks since it requires only a selection from a limited number of possibilities.

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Note

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Transfer in repaired S₁-R₂ and S₂-R₁ paradigms¹

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Four two-list paired-associate transfer paradigms (A-B, B-A_r; A-B, B'-A_r; A-B, B-A_r; A-B, B-C) were compared with an A-B, C-D control condition. In accordance with predictions made from a transfer surface described by Houston (1965), negative transfer appeared in all four experimental conditions. In contrast to the surface predictions that maximum negative transfer would occur in the A-B, B-A_r situation, that minimum negative transfer would appear in the A-B, B-C paradigm, and that the remaining conditions would display intermediate amounts of negative transfer, the four experimental paradigms did not differ in terms of second-list learning.

Houston (1965) has described a surface which summarizes transfer effects expected in two-list paired-associate paradigms varying in S₁-R₂ and S₂-R₁ similarity when the first-list units are repaired in the second lists. According to this surface, negative transfer should increase as S₂-R₁ similarity increases. This increase should be greater when S₁-R₂ similarity is high than when it is low. The present study was designed to test several points on the surface. Specifically, Ss learned two paired-associate lists conforming to one of the following paradigms: A-B, C-D; A-B, B-A_r; A-B, B'-A_r; A-B, B-A_r; A-B, B-C. The A-B, C-D condition is, of course, the control against which transfer in the remaining paradigms is judged. According to the surface all four experimental conditions should yield negative transfer, with the A-B, B-A_r situation displaying the greatest amount of transfer and the A-B, B-C arrangement producing the least. The remaining experimental paradigms were expected to yield intermediate, and perhaps equivalent, amounts of negative transfer. The rationale for these predictions is detailed in the Houston (1965) paper.

Method

The Ss were 100 University of California undergraduates whose experimental participation was in fulfillment of a course requirement. The five paradigm conditions were randomized 20 times such that each occurred once in each successive block of five Ss. The Ss were assigned to this arrangement of conditions as they appeared in the testing situation. All Ss learned two PA lists corresponding to one of the five paradigms. The PA lists were composed of eight pairs of common adjectives chosen from Haagen's (1949) lists. As is the usual procedure in transfer studies, the second list remained constant across conditions while the first lists differed in each condition. Two different pairings of the 8 second-list stimuli and responses were developed and each was assigned to half the Ss in each condition. For each second-list five different first lists were developed such that each corresponded

to one of the paradigms under investigation. Repairing in the A-B, B-A_r condition amounted to insuring that particular A and B units which were paired together in the second list were not paired together in the first list. In the A-B, B-A_r paradigm, the first lists were constructed such that similar A and A' units were not paired with the same B units. Similarly, in the A-B, B'A_r situation similar B and B' units were not paired with the same A units. The Haagen (1949) similarity ratings of the similar words were 2.1 or better. When not intended, inter- and intralist meaning similarity were minimal. The words within the sets of stimuli and responses began with different letters. No two members of a given pair of words began with the same letter. Five different presentation orders of each list were employed to minimize serial learning. Each order was used equally frequently as the starting order. All learning was at a 2:2 sec. presentation rate with a 4 sec. intertrial interval on a Stowe drum. A 1 min. interval separated the learning of the two lists. The Ss were given 6 anticipation trials on both lists.

Results

The mean numbers of correct first-list responses given by the C-D, B-A_r, B-C, B-A_r, and B'A_r groups were 18.20, 19.50, 18.35, 21.30, and 18.25, respectively. An analysis of variance did not indicate significant differences among these means, $F < 1$. The mean numbers of correct second-list responses given by the C-D, B-A_r, B-C, B-A_r, and B'A_r groups were 29.20, 21.65, 21.20, 20.40, and 18.75, respectively. An analysis of variance revealed significant differences among these means, $F = 3.99$, $df = 4/95$, $p < .01$. Subsequent Newman-Keuls comparisons indicated that the C-D mean was significantly greater than the B'-A_r mean at the .01 level and greater than the remaining means at the .05 level. None of the other comparisons were significant. Thus it seems that significant negative transfer occurred in all paradigms but that the amounts of transfer did not differ from paradigm to paradigm. In an attempt to determine the extent to which transfer occurred early in learning the numbers of correct responses given during the first three second-list trials were tabulated. The means for the C-D, B-A_r, B-C, B-A_r, and B'A_r conditions were 5.50, 3.65, 3.60, 3.70, and 2.75, respectively. The overall analysis of variance was again significant, $F = 3.01$, $df = 4/95$, $p < .05$, but in this case the only significant individual comparison was between the C-D and the B'A_r means, $p < .05$. It would appear that early learning was less affected than overall second-list learning.

Because the surface predictions are based, in part, upon the assumption that backward first-list associa-

tions compete with the formation of forward second-list associations, first-list stimuli occurring as second-list responses were tabulated. As expected, the greatest number of these kinds of errors occurred in the A-B, B-A_r paradigm. During second-list learning A units were given as responses to the B units that they had been paired with in the first list 49 times. In A-B, B'-A_r second-list learning, A units which had been paired with particular B units in the first list occurred as responses to the corresponding B' units 27 times. In second-list A-B, B-A_r learning, A units occurred as responses to the B units that they had been paired with in the first list 7 times. First-list stimuli occurred as second-list responses once in each of the A-B, C-D and A-B, B-C conditions.

In summary, the principal finding of the present study was that significant negative transfer occurred in all four experimental paradigms but that the amounts of transfer in these situations did not differ. This is in agreement with the hypothesis that negative transfer will occur in these situations but it does not support the prediction that this negative transfer will increase as S₁-R₂ similarity increases.

Following the completion of this experiment two additional groups of 20 Ss were tested. The materials and procedures used in these tests were the same as those used in the main experiment. In an attempt

to determine if the A-B, B-A_r result obtained in the main experiment was reliable, the first of these supplementary groups was tested with the A-B, B-A_r paradigm. The mean number of correct second-list responses produced by this group (19.10) was in close agreement with the main experimental mean of 20.40. The second supplementary group was tested with the A-B, C-A paradigm. Houston (in press) failed to find significant transfer in this condition while Murdock (1958) reports the appearance of significant negative transfer. The second-list learning mean obtained with this supplementary A-B, C-A group (23.50) was not significantly different from the main experimental control mean of 29.20 ($t = 1.78$, $df = 38$).

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Note

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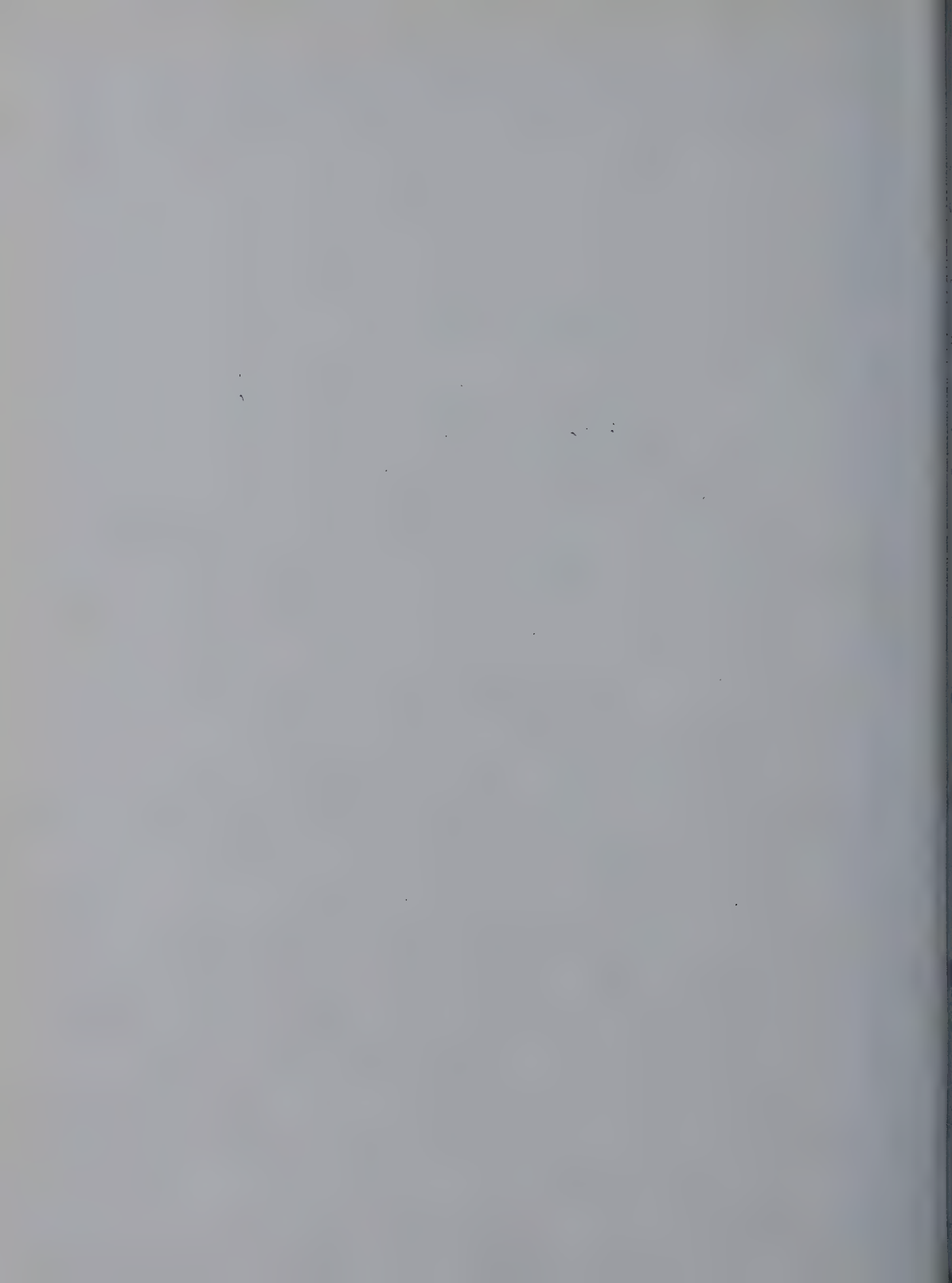
PSYCHONOMIC MONOGRAPH SUPPLEMENTS

1. William F. Battig. Procedural problems in paired-associate learning, 1965, pp. 12. \$1.00
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Chronic electroshock: Effects on brain weight, brain chemistry, and behavior¹

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Minimum or maximum electroshock convulsions administered chronically to rats resulted in increased brain weight, total brain cholinesterase activity, total protein, and total acetylcholinesterase activity depending upon whether or not full convulsions were induced and on the frequency of their induction over a 17-20 week period. Convulsed rats made more errors in an underwater T-maze than rats given subconvulsive shocks or sham controls.

Bennett et al (1964) reported that rats maintained in an "enriched" environment for 80 days developed heavier cortices and higher total activities of cholinesterase (ChE) and acetylcholinesterase (AChE) than littermates raised in isolation. They attributed these changes to the different opportunities for learning under the two conditions. To investigate the possibility that stimulation of the nervous system, per se, without experiential differences, is sufficient to produce these or similar changes, we stimulated the nervous system of rats by repeated electroshocks for 17-20 weeks.

Method

We used 78 Wistar rats of both sexes. Animals were housed one per cage and food and water were given ad lib. At 30 days of age, the animals were formed into two groups. Group I was given one treatment per week for 20 weeks and Group II, three treatments per week for 17 weeks. Each group was further divided into three subgroups: a maximal seizure group, a threshold seizure group, and a sham control group.

Electroshock (ES) was delivered via ear clips from a constant current stimulator (60 cps ac for 0.2 sec.). Current intensity varied for each animal during the experiment and was re-estimated before each treatment using the procedure of Woodbury & Davenport (1952). The maximal seizure groups were stimulated with an intensity just sufficient to produce a full tonic-clonic convulsion. The threshold seizure groups were given as much current as necessary to elicit a minimal threshold seizure, characterized by clonus of the vibrissae and ears. The sham control groups received the same treatment as the ES groups except that no current was administered.

Three days after termination of the treatments, all animals were given three behavioral tests. The first two tests—a 2-hr. test of motor activity and a 15-min. "timidity" test (in which time to emerge from a wire cage onto a black table top was measured)—were given to determine whether or not the treatments had resulted in gross changes in motor activity and/or emotionality. The third test—a spatial discrimination learn-

ing task in an underwater T-maze—was given to determine whether electroshock stimulation of the brain would result in increased learning ability. Bennett et al (1964) reported that "enriched" environment rats performed better than isolated littermates on a discrimination reversal problem. In the learning test, two trials were given 1 hr. apart. The choice made on the first, training, trial was defined as incorrect for all animals; that is, escape was blocked after the choice was made so that the animal had to retrace to the non-preferred side to escape. During the second, test, trial the non-preferred side on trial 1 was defined as correct.

After behavioral testing was completed, the animals were sacrificed; whole brains were removed rapidly and weighed, and stored on dry ice until chemical analyses for ChE and AChE activities and percent protein were made.

Results and Discussion

The results of the experiment are summarized in Table 1. Sexes were combined since the responses to the treatments did not differ significantly between males and females.

In the "timidity" test, the proportion of animals in both threshold groups that emerged was lower than in the sham control and maximal seizure groups, in that order, but the differences were not significant.

There were no significant differences in motor activity scores for animals in Group I. The threshold seizure group of Group II had significantly lower motor activity scores than the sham control and the maximal seizure groups; the latter two did not differ from each other.

For the spatial discrimination test in the underwater T-maze, the maximal seizure groups made fewer correct choices on the test trial than the sham control and the minimal seizure groups, in that order. The differences among the groups were statistically significant only for those animals treated three times a week.

Brain weight increased as a function of the intensity of the treatment and its frequency. For Group I, the differences just failed to reach the 5-percent level of significance. For Group II, the differences were significant well beyond the .001 level of confidence. Since the body weights of the treated animals were generally lower than those of the controls, the increased brain weight of ES animals cannot be accounted for by differences in body weight between the groups. Also, the absence of any changes in percent protein

Table 1. Effects of Chronic Administration of Electroshock on Behavior, Brain Weight, and Brain Chemistry

Frequency	Treatment	n	Timidity ^a	Motor Activity ^b	T-Maze ^c	Body Weight(g)	Brain Weight(g)	Protein (%)	ChE Activity ^d	AChE Activity ^e
One per week	Sham control	6	0.33	697	0.67	366	1.95	13.8	3.2	96.6
	Threshold	13	0.31	671	0.69	398	2.02	14.2	3.2	98.3
	Maximal	16	0.38	526	0.38	348	2.02	13.8	3.2	93.2
	Significance ^f		N.S.	N.S.	N.S.	<.01	<.10	N.S.	N.S.	<.01
Three per week	Sham control	12 ^g	0.50	684	0.45	392	1.99	12.7	4.4	109.1
	Threshold	13 ^g	0.38	431	0.83	371	2.01	13.0	4.4	105.0
	Maximal	12	0.58	738	0.33	377	2.12	13.1	4.3	108.6
	Significance ^f		N.S.	<.025	<.05	N.S.	<.001	N.S.	N.S.	N.S.

(a) Proportion of exits in 15 min. (b) Mean total revolutions in 2 hrs. (c) Proportion of correct choices on trial 2. (d) Moles AcSch hydrolysed/min/mg of tissue $\times 10^{10}$ under our conditions. (e) Moles BuSch hydrolysed/min/mg of tissue $\times 10^{10}$ under our conditions.

(f) Based on analysis of variance among groups (no valid comparison can be made between groups treated once per week and three times per week since there were confounding factors present, viz., times of testing, sacrifice and chemical analyses. (g) One animal drowned during the spatial discrimination test.

among the groups is evidence against the interpretation that the brain weight changes were due to edema.

There were no significant differences among any of the groups in specific ChE activity (activities per unit weight), indicating that total activity (activity per whole brain) increased in proportion to the increases in tissue weight. There was a decrease in the specific activity of AChE for the group receiving maximal seizures once a week, and a slight, though insignificant, decrease in the specific activity of this enzyme for both groups treated three times per week. This suggests that total AChE activity did not increase in proportion to the increase in weight in the weekly group, whereas ES three times a week was sufficient to produce enzyme changes commensurate with the weight changes. Independent changes in weight and enzyme activity were also reported by Bennett et al (1964).

We tentatively interpret these results as follows: Electrical stimulation of the brain is sufficient to increase brain weight and the activity of enzymes thought to be involved in neural transmission. These changes are related either to the intensity of the electroshock current or to the occurrence or non-occurrence of a full convulsion or both; frequency (and possibly the spacing) of electroshock stimulation is also a factor. Changes in brain weight and enzyme activities, however, do not necessarily reflect an increased learning ability as found after patterned stimulation from an "enriched environment." This may be due to the diffuse nature of the stimulation resulting from ES and the well known but unexplained amnesic effect of electroconvulsive shock on recently learned responses.

The behavioral results generally agree with published reports on the effects of multiple ESs on behavioral measures similar to those used in this experiment. The increase in "timidity" and reduction

in motor activity by the threshold groups are in accord with data reported by McGaugh & Madsen (1964), showing that ES increases the number of immobility responses, defined as freezing and crouching. They also found that subconvulsive shocks were more effective in this respect than convulsive shocks.

The differences in learning a relatively simple spatial discrimination among the groups deserves some comment. Weissman (1963) found that electroconvulsive shock produced retrograde amnesia in a one-trial avoidance task, whereas subconvulsive currents had no such effect, a result consistent with our finding that only the maximal seizure groups had impaired performance. Thus, maximal seizure animals may not have been able to consolidate learned habits normally accumulated from daily living that may have been useful during problem solving in the maze; each ES could have erased such experiences as they occurred. The minimal seizure groups would not be expected to accumulate such a deficit since memory deficit has not been demonstrated in animals given subconvulsive electroshock.

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Note

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Effects of prenatal hypoxia upon activity and emotionality of the rat¹

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Gravid female rats were made hypoxic on the eighth or twentieth day of term. Their progeny were found to be more active in an avoidance shuttle box. These results are contrasted to similar studies measuring activity in non-noxious circumstances. Also, the experimental Ss were found to be hypoemotional in comparison to their controls as measured by a rating scale and weight loss during avoidance training. The offspring of animals treated on the eighth day of gestation were less emotional than those receiving treatment on the twentieth day, confirming other studies demonstrating behavioral differences linked to prenatal age at treatment.

Recent evidence indicates that the behavioral dimensions of emotionality and activity are extremely sensitive to various perinatal treatments, including the following: oxygen deprivation (Saxon, 1961a, 1961b; Becker, 1958; Vierck & Meier, 1963), X-irradiation (Werboff et al, 1962), drug injection (Werboff et al, 1961; Werboff & Havlena, 1962), and even water vs. saline or intraperitoneal vs. subcutaneous injection (Werboff & Havlena, 1962).

Hypoxia, administered neonatally to monkeys (Saxon, 1961a, 1961b) renders the experimental animals hyperactive in a novel environment, hypoactive after adaptation to the testing environment, and generally hypoemotional. Prenatal hypoxia in mice, if given late in gestation, produces identical activity results, but the animals treated early become generally hypoactive (Vierck & Meier, 1963). The present study extends these findings to prenatal hypoxia of the rat.

Method

Two groups of four, gravid, female rats of the Wistar strain were made hypoxic on the eighth (H8) and twentieth (H20) days of term, and their progeny comprise the experimental animals of this study (H8, N=10; H20, N=25). The control group (C) consisted of four litters from untreated mothers (N=23). Hypoxia was induced by evacuating air from a dessicator at a rate which maintained a simulated altitude of 33,000 ft. for 6 hr. (including 20 min. rise and fall times).

Emotional behavior was rated numerically by assigning a value of from zero to five according to strength of reaction to each of six components. As described by King (1958, p. 58), the emotional components are: (a) attack or flight reaction to a pencil presented visually to the S's face, (b) startle and flight reaction to tactile stimulation of the animal's back, (c) resistance to capture, (d) muscular tension and resistance to handling, (e) vocalization during testing, (f) urination and defecation during testing. A

further measure related to emotionality was obtained by recording the amount of weight lost during five 1/2-hr. avoidance conditioning sessions. Forty conditioning trials per day were randomly presented in time and consisted of the sounding of a tone until the animal crossed into the opposite compartment of the shuttle box. If the animal did not respond correctly within a 5-sec. avoidance period, shock was applied to its feet until crossing occurred. Efficiency of learning was measured as percent avoidance responses, and level of activity was assessed by recording the total number of crossings between compartments of the shuttle box. The latter measure included 40 avoidance or escape crossings in each daily session.

Results

As seen in Fig. 1B, both groups H8 and H20 exhibited consistent hyperactivity as compared to the control group. These differences were frequently significant (solid symbols in Fig. 1) and were maintained over five consecutive days of avoidance testing, even

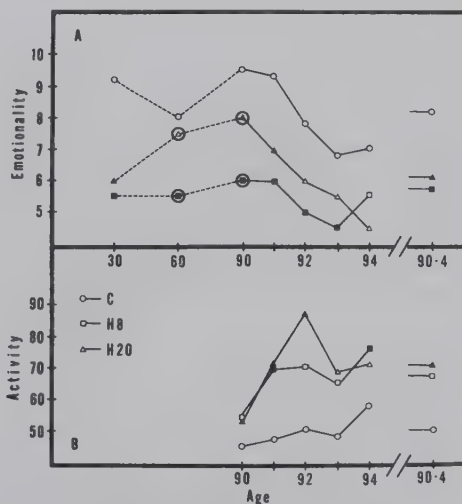


Fig. 1. Median emotionality ratings (A) and mean activity scores (B) for the three groups at different ages of testing. Solid symbols indicate statistically significant differences between control and experimental groups (5% level). Encircled symbols denote significant differences between groups H8 and H20. The statistical tests used were the Mann-Whitney U for emotionality and t-test for activity. The number of subjects was as follows: 30 and 60 days, C = 23, H8 = 10, H20 = 25; 90 - 94 days, C = 10, H8 = 7, and H20 = 7. Animals in the smaller groups (90 - 94 days) were randomly selected from the larger groups with the provision that all litters be represented.

though the experimental groups received fewer shocks in the shuttle box. The mean percent conditioned responses over 200 trials were: C=40.8, H8=52.2, H20=51.0 (differences between groups not significant).

The emotionality rating scale revealed consistent hypoemotionality for groups H8 and H20 (Fig. 1A). These differences were maintained from 30 to 90 days of age and held up over five consecutive days of testing (90-94 days). In addition, group H8 was consistently less emotional than group H20 (circled symbols in Fig. 1 indicate significant differences on days 60 and 90). In support of the emotionality rating data, groups H8 and H20 lost significantly less weight than the control group during individual avoidance conditioning sessions, indicating less urination and defecation in response to stress. The weight loss data were adjusted by the analysis of covariance procedure (Cochran & Cox, 1950) to control for the number of shocks received by each animal. The mean weight losses in grams before and after adjustment were: C=7.2, 2.3; H8=3.2, -0.9; H20=3.6, -0.6.

Neurological examination revealed no differences between groups, except that a greatly attenuated startle response to an intense auditory stimulus (hand clap) was observed for group H8. The H8 rats were not deaf as indicated by efficient responding to an auditory CS in the shuttle box.

Discussion

The results of this study lend a good deal of generality toward identification of an hypoxic behavioral syndrome involving activity and emotionality. Some part of the emotionality-activity pattern has now been demonstrated with neonatal treatment of monkeys (Saxon, 1961a, 1961b) and guinea pigs (Becker, 1958) and prenatal treatment of mice (Vierck & Meier, 1963) and rats. In these studies, hypoemotionality among treated animals has been demonstrated with the following measures: observation of behavior in an open field, reaction to electric shock, reaction to handling and prodding, and excretion under stress. In the present study, hypoemotionality of group H8 with respect to group H20 extends previous findings that Ss deprived of oxygen early in gestation learn a maze faster (Meier et al, 1960) and are less active (Vierck & Meier, 1963) than late deprived animals.

All hypoxic Ss maintained hyperactivity over five consecutive days of testing, in contrast to previous studies showing consistent hypoactivity (early treated group) or reversal from hyper- to hypoactivity within this period (late treated groups). Possibly the intense stress conditions created by electric shock were re-

sponsible for hyperactivity of the early treated group (H8) in this study, environmental novelty not providing sufficient activation in the previous study. The same explanation would apply to consistent hyperactivity among the late treated group (H20), environmental novelty being an adequate activator to comparable groups in the other studies. Thus, hypoxic animals may be characterized as somatically energized under stress (novel environment or electric shock conditions) and sluggish in familiar surroundings. This pattern corroborates the clinical findings of Preston (1945), who studied children with histories of hypoxia at birth and noted hyperreactivity under stress but otherwise profound lethargy. Strikingly similar results have also resulted from prenatal irradiation (Werboff et al, 1962), all experimental groups exhibiting hypoemotionality, early irradiated groups demonstrating hypoactivity, and late irradiated groups showing hyperactivity.

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Notes

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2. Now at Department of Pathology, Dartmouth Medical School.

Classical conditioning of reflexive fighting¹

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This study demonstrated that reflexive fighting could be classically conditioned to a 80-db buzzer, using both simultaneous and delayed conditioning paradigms.

Fighting responses are consistently elicited by the delivery of electrical foot shock to pairs of rats (Ulrich & Azrin, 1962). Since this behavior occurs in the absence of prior conditioning, shock elicited fighting has been defined as an unconditioned reflex (Ulrich & Azrin, 1962). If fighting is a UCR, then it should be amenable to classical conditioning procedures. The present study attempted to condition fighting responses to a buzzer using simultaneous and delayed conditioning processes.

Subjects and Apparatus

The Ss were 10 male and two female experimentally-naïve Sprague-Dawley rats about 120 days old. Each of the six pairs of Ss were matched for weight and sex.

The apparatus consisted of a Grason-Stadler E3125B test chamber and a E1064GS shock source. The door of the test chamber was left open to permit an unobstructed view of the Ss. Two buzzers, 45 db, 60 cps, and 80 db, 4000 cps (modulated by a 60-cps tone), respectively, were mounted on the wall of the test chamber. The conditioning paradigms were programed by electromechanical apparatus. Fighting responses and shock and buzzer presentations were recorded by counters and a four-pen polygraph.

Procedure and Results

Azrin et al (1964) have reported that 2 ma shocks of 0.5 sec. duration, presented at a frequency of 20 shocks per min., are the optimal UCS parameters for eliciting fighting in paired animals. These shock parameters were used in the present study.

Fighting responses were defined and recorded in the manner suggested by Ulrich & Azrin (1962). Two Es independently depressed switches to record striking movements that occurred with each shock presentation, or in the case of test trials, with each buzzer presentation. Greater than 95% agreement was obtained between the two Es in recording fighting responses.

Simultaneous conditioning

Each pair of rats was first placed in the chamber and given random, unpaired presentations of the CS (40-db buzzer) and the UCS (shock) to test for sensitization. Fighting was elicited by the UCS, but not by the CS.

In the simultaneous conditioning procedure, the CS and the UCS were presented and terminated simultaneously. Pair 1 was presented with 400 UCS-CS pairings during the first daily session and 300 pairings each day, for two more sessions, for a total of 1000 UCS-CS pairings. Pairs 2 and 3 were given 900 UCS-CS pairings, 300

per day, over the same period. On the fourth day, after having presented each pair with an additional 100 UCS-CS pairings, 25 test trials of the CS only were given. These test trials elicited a standing posture, but no fighting responses.

The three pairs were then presented with an additional 600 UCS-CS pairings, 300 per day, for two more sessions. During the third session, the animals were first given 210 UCS-CS pairings followed by a CS only test trial. Ten additional UCS-CS pairings and another test trial were then presented. This sequence of 10 UCS-CS pairings, followed by a test trial, was repeated nine times for each pair of Ss. No fighting responses were observed, although the standing posture described above was elicited again.

At this time, the 45-db buzzer was replaced by the 80-db buzzer. Each of the three pairs was retested for sensitization by presenting random, unpaired UCS-CS presentations. Once again, fighting was elicited only by the UCS.

Pair 1 was then presented with 130 UCS-CS pairings followed by a test trial. Ten additional UCS-CS pairings were then given and another test trial presented. This sequence of 10 UCS-CS pairings, followed by one test trial, was repeated seven times during the session. Five fighting responses were observed during the eight CS only test trials. Pairs 2 and 3 were each presented with 110 UCS-CS pairings followed by a test trial. Ten additional UCS-CS pairings were given and another test trial presented. This sequence of 10 UCS-CS pairings, followed by a test trial, was repeated nine times during the session. Fighting responses were elicited by the CS only with both pairs. All Ss were then tested for

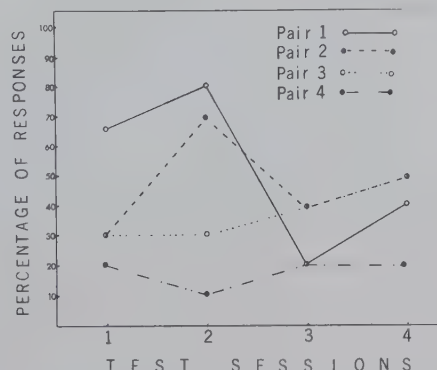


Fig. 1. The percentage of fighting responses that were elicited by the CS only during all four test sessions for the four pairs of Ss used in the simultaneous conditioning procedure.

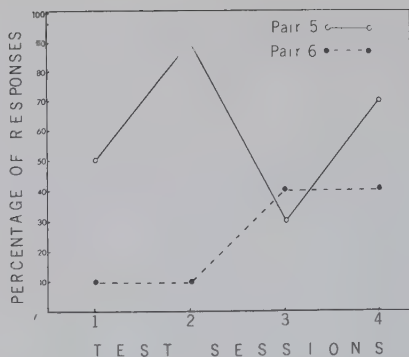


Fig. 2. The percentage of fighting responses that were elicited by the CS only during all four test sessions for the two pairs of Ss used in the delayed conditioning procedure.

three more sessions in the manner described for Pairs 2 and 3. The percentage of fighting responses elicited by the CS only for the three pairs during all four test sessions is shown in Fig. 1.

To determine the reliability of the above results, Pair 4 was given 1500 UCS-CS pairings over a five-day period. During the sixth session, testing took place exactly as described above for Pairs 2 and 3. Three fighting responses were observed during the 10 presentations of the CS only in the first test session. This same testing procedure was carried out for three additional sessions. The percentage of fighting responses elicited by the CS alone during all four test sessions is also shown in Fig. 1.

Delayed conditioning

Pairs 5 and 6 were then tested for sensitization in the manner described above for the Ss employed in simultaneous conditioning. Fighting responses were elicited by the UCS, but not by the CS.

In the delayed conditioning procedure, the 80-db buzzer (CS) came on 0.5 sec. before the UCS was delivered and terminated simultaneously with the UCS onset. Each pair of Ss was presented with a different number of UCS-CS pairings before testing occurred. After 110 pairings of the CS and UCS, Pair 5 was given one test trial of the CS only. The pair was then given 10 additional UCS-CS pairings followed by another test trial. This sequence of 10 UCS-CS pairings, followed

by a test trial, was repeated nine times. Five fighting responses were observed during these 10 presentations of the CS only. An identical procedure was carried out for three more sessions. The percentage of responses elicited by the CS only during these four test sessions for Pair 5 is shown in Fig. 2.

Pair 6 was presented with 10 UCS-CS pairings followed by a test trial presentation of the CS only. This sequence of 10 UCS-CS pairings followed by a test trial was repeated 10 times. No fighting responses were elicited by the CS only. The same procedure was repeated the following session. Again, no fighting responses were elicited by the CS only. During the third session, Pair 6 was treated in a manner similar to that described for Pair 5, i.e., after 110 pairings of the CS and UCS, one test trial was given, etc. One fighting response was elicited during the 10 test trial presentations of the CS only. An identical procedure was carried out for three additional sessions. The percentage of fighting responses that occurred in the presence of the CS only during all four test sessions for Pair 6 is also shown in Fig. 2.

Discussion

From the results of this study, two factors emerge as potential determinants of the acquisition of conditioned reflexive fighting. The first concerns the intensity of the CS. Whereas no conditioned fighting responses were obtained using the 40-db buzzer as a CS, conditioned fighting responses were elicited when the 80-db buzzer was used as the CS. Secondly, the delayed conditioning paradigm was found to be a more efficient procedure for eliciting conditioned fighting responses than was the simultaneous conditioning paradigm. This latter finding agrees with previous studies which have compared the relative effectiveness of delayed and simultaneous classical conditioning procedures for a variety of conditioned responses (Kimble, 1961).

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Note

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Effects of hippocampal lesions on food and water consumption in rats¹

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UNIVERSITY OF OREGON

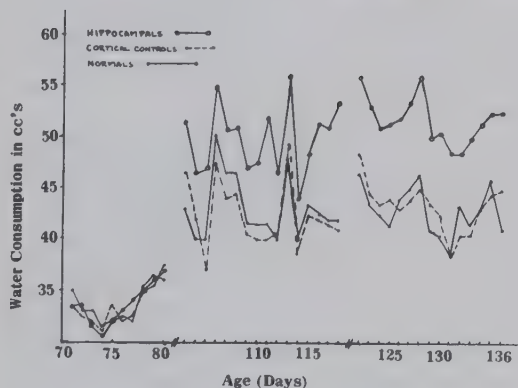
Rats with bilateral hippocampal lesions drank 16-21% more water postoperatively than Ss receiving posterior neocortical lesions or unoperated controls. Data were based on ad lib intake measures over 2 months following surgery. Both lesioned groups consumed slightly more food than unoperated Ss. No differences in body weights developed.

The manner in which the hippocampal formation participates in behavior remains in doubt. However, Green (1964) and Grastyan et al (1965) have suggested that the clear anatomical connections between the hippocampus and the hypothalamus may provide functional clues, and Pribram (1960) and de Groot (1965) have theorized that the limbic system may act to bias or modulate hypothalamic homeostats regulating the organisms *milieu interieur*. Since there is little direct evidence in rats regarding the role of the hippocampus in the regulation of food and water intake, the present experiment was undertaken to explore this problem by examining ad lib food and water consumption in rats with hippocampal lesions.

Method

Ss were 39 male, experimentally naive Sprague-Dawley rats obtained from Carworth Farms, N. Y., 70 days old at the beginning of the experiment. There were 15 unoperated controls. Twelve Ss received bilateral hippocampal lesions, and 12 received bilateral lesions of the neocortex overlying the hippocampus. All operations were performed over a 13 day span by aspiration in one stage, under Nembutal (50 mg/kg) anesthesia, as detailed previously (Kimble, 1963).

Food (Simonsen's white diet) and water were continually available. Daily ad lib food and water consumption measures were taken for 10 days prior to surgery. A container under each cage caught crumbs; these as well as leftover food were weighed so that any differential "sloppiness" would be detected. Leakage from the water bottles was measured as < 2% of the average preoperative daily intake. Three experimental groups were made up on the basis of these preoperative consumption measures to insure equal preoperative



group means. The preoperative consumption was compared with that for two postoperative periods; Period 1 lasting from Day 20-38 after the first surgical day, and Period 2 lasting from Day 42-59.

Results

The hippocampal rats consumed 21% more water than either of the other experimental groups during Period 2; 16% more during Period 1 (see Figure). A mean daily intake measure was obtained by collapsing data over each of the three periods for each S. A test of the validity of the assumptions underlying the analysis of covariance was significant. This was due to a difference in regression line slopes (for Period 2, the slopes are 1.27, -.002, and 1.93 for normals, cortical operates, and hippocampals, respectively). There was, therefore, an interaction between the locus of the lesion and preoperative drinking level. Only the slope for the cortical operates was significantly different from the other two. Since the planned analysis of covariance was not allowable, a rank order test was performed. For Period 1, $\chi^2 = 4.3$ (.1 < p < .2) and for Period 2, $\chi^2 = 8.0$ (p < .025). The difference between the hippocampal Ss and either of the other groups for Period 2 was significant (p < .025) with a Wilcoxon-Mann-Whitney test.

Table 1. Mean and standard deviations, daily food and water consumption: Normal, cortical operates and hippocampal rats.

Group	N	Preoperative		Postoperative			
		Food	Water	Period 1 Food	Period 1 Water	Period 2 Food	Period 2 Water
Unoperated	14 ²	21.2 (± 2.0)	33.7 (± 6.9)	21.9 (± 1.6)	42.8 (± 10.0)	20.7 (± 1.5)	43.1 (± 10.7)
Cortical operates	12	21.0 (± 1.6)	33.5 (± 5.5)	22.7 (± 1.9)	42.2 (± 6.6)	21.3 (± 1.4)	43.1 (± 6.4)
Hippocampals	12	21.2 (± 1.3)	33.6 (± 4.3)	23.2 (± 1.7)	49.6 (± 10.6)	21.8 (± 1.5)	52.1 (± 10.3)

Comparison of individual means also revealed that while the hippocampal Ss ate significantly more food ($<.05$) than the unoperated Ss, for each of the 2 periods, the cortical operates fell in the middle, and did not differ significantly from either of the other groups. Throughout the consumption measurement periods, the group means of body weight were practically identical, varying $<3\%$ among groups. Operated Ss typically regained their preoperative body weight by the 6th postoperative day.

Discussion

The increased water consumption in the hippocampal rats is the major finding of this experiment. This finding is complicated somewhat by the interaction between lesion locus and preoperative drinking levels. A possible interpretation is that the increased drinking due to lesion is a percentage of preoperative intake, which would account for the increased slope of the hippocampal rats. For the cortical operates, who show a decrease if they are initially big drinkers but cannot withstand much drop if they are small drinkers, this results in a more marked decrease in regression line slope, but less marked decrease in group mean.

The intermediate position of the cortical operates on food consumption makes it likely that the removal of neocortical tissue as well as the paleocortical tissue of the hippocampus may be a factor in the slight increase in postoperative eating observed in our rats.

The increased water consumption in the hippocampal rats appears related to the data of Harvey & Hunt (1965). They found a 37-59% increase in ad lib water intake following septal lesions in Sprague-Dawley rats. The anatomical connection between the septal nuclei and the hippocampus (the fornix) is well known. Whether our hippocampal Ss will also behave such as to maximize the number of rewards in water reinforced operant situations as did the septal rats of Harvey & Hunt (1965) is now under investigation, although Clark & Isaacson (1965) have already reported that their hippocampal Ss did not so behave on either a DRL or CRF schedule.

It is not possible at this stage to explain the increased water consumption. Kim (1960) has reported that small, electrolytic lesions did not affect basal metabolic rate in rats. It is possible that our effects are related to the effects of septal lesions on adrenal function (Lissak & Endroczi, 1961). Whatever the explanation, the present data indicate that it may be necessary to take account of possible increases in water consumption when evaluating the behavior of rats with hippocampal lesions.

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Notes

1. This investigation was supported in part by a USPHS Grant MH 08545-02, D. P. Kimble, principal investigator, and a USPHS predoctoral fellowship to G. D. Coover.
2. The data from one unoperated S was discarded because his water intake tripled within 3 weeks of the preoperative period. Statistical tests for outliers revealed that he was an outlier ($p < .005$). Inclusion of his data does not affect the food results at all, and the effect on the water results is to lower all probability levels to $<.05$.

Cortical control of specific and nonspecific sensory projections to the cerebral cortex¹

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Activation of the frontal association response field of the cerebral cortex of cat by a brief train of electric shocks is shown to induce a subsequent marked depression of nonspecific evoked cortical association responses and an enhancement of the later components of evoked primary sensory responses. Both effects have been reported to accompany behavioral attending. The two effects of cortical stimulation can be differentiated by drug actions: strychnine abolishes the depression of association responses and picrotoxin abolishes the enhancement of primary responses. It is suggested that the frontal association response field may play a crucial role in the control of specific and nonspecific sensory projections to the cerebral cortex.

When an organism "attends" to a sudden sensory stimulus, two seemingly opposite changes occur in cortical responses evoked by the stimulus. The later components of primary sensory responses recorded from the human scalp increase in amplitude (Davis, 1964; Haider, Spong, & Lindsley, 1964). Nonspecific evoked responses recorded from association cortex of the cat, on the other hand, are markedly depressed (Shaw & Thompson, 1964; Thompson & Shaw, 1965). This report will show that a single maneuver, electrical activation of the frontal cortex, can produce both types of changes in cortical activity.

Method

Cats were anesthetized with 70 mg/kg of α -chloralose (IP), and the cerebral cortex exposed. Cortical evoked responses were recorded with a gross monopolar surface electrode, using standard techniques. Series of individual responses and computer (Enhancetron) averaged responses were obtained. The electrical stimulus to the frontal cortex was a train of 10 pulses, of .2 msec. duration each at a frequency of 250/sec., from a Tektronix 161 pulse generator delivered through an isolation transformer to two silver ball electrodes placed 2 mm. apart on the cortex. Peripheral stimuli were light flash, free field click, or skin shock, presented at various times (0 to 500 msec.) after onset of the 40 msec. cortical shock train. In drug experiments chloralosed animals were first immobilized with Flaxedil (IV) and then administered IV doses of strychnine (0.2 mg/kg) or picrotoxin (2 mg/kg).

Results

Electrical stimulation of frontal cortex produced a marked depression of nonspecific association responses and an enhancement of the later components of primary sensory responses. The effects began about 10 msec. after onset of cortical shock train, reached a maximum

at 50 to 80 msec. and were over by about 300 msec. The areal distribution of relative effectiveness of cortical shock train on the frontal cortex was virtually identical to the relative amplitude distribution of evoked association responses in this region (Thompson, Johnson, & Hoopes, 1963), with maximum effectiveness about 3 mm. anterior to the cruciate sulcus. The effects could still be obtained by precruciate stimulation after ablation of somatic sensory area I. Stimulation of somatic sensory area I was relatively ineffective.

Data shown in Fig. 1 illustrate the effect of increasing cortical stimulus intensity on the amplitude of specific and nonspecific cortical evoked responses. Peripheral stimuli were given 70 msec. after onset of the 40 msec. cortical shock train. Inset drawings in Fig. 1 identify the components of the association and primary evoked responses plotted in the graphs. The initial positive component (P_1) of nonspecific responses to all three types of peripheral stimuli, recorded from the middle suprasylvian and anterior lateral association areas, was markedly depressed in an equivalent manner by the cortical shock train. In contrast, the initial positive component (P_1) of primary responses recorded from areas AI to click, VI to light flash, and SI to forepaw shocks, was not

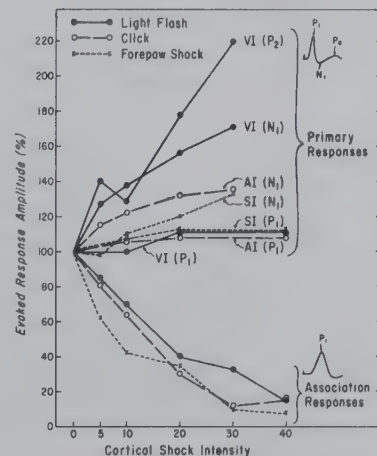


Fig. 1. Effect of intensity of cortical shock train to frontal cortex on primary and association cortical responses evoked by sensory stimuli. Various components of the evoked responses (identified by insets—positive up) are plotted separately. Abscissa scale refers to stimulator (Tektronix 161) settings.

depressed. In fact there was a slight (10%) but statistically significant increase in response amplitudes following strong cortical shocks. The subsequent negative component (N_1) of all three types of primary response exhibited a substantial increase in amplitude with increasing cortical shock intensity. Finally, the afterpositivity (P_2) of the primary visual response (the only type of response where P_2 could be obtained reliably) was markedly enhanced by the cortical shock train.

The increases in later components of primary cortical responses following cortical shock are strikingly comparable to the increases in human evoked response components during "attention" recently described by Spong, Haider, & Lindsley (1965). Response components from their data were identified in terms of waveforms, polarities, and peak latencies that corresponded to the response components defined in our experiments. Thus, for the primary visual evoked response, their data indicated an increase of about 75% in the N_1 component, compared to a 70% increase in our experiments, and an increase of about 150% in the P_2 component, compared with an increase of 120% in our experiments (see Fig. 1).

The actions of two inhibitory blocking agents, strychnine and picrotoxin, on the effects of cortical shock on association and primary responses were explored. Strychnine totally abolished the depression of association responses following cortical shock, but did not alter the enhancement of primary responses. Picrotoxin, on the other hand, abolished the enhancement of primary responses, but did not alter the depression of association responses.

Discussion

The results of these experiments indicate that electrical activation of the frontal association response field of the cortex can reproduce both the depression of association cortical responses and the enhancement of the later components of primary cortical responses that accompany behavioral attending. This region of the cortex may well play a crucial role in the control of both specific and nonspecific input to the cerebral cortex. Krauthamer & Albe-Fessard (1965) recently reported that electrical activation of the basal ganglia depresses cortical association responses without influencing primary responses. It may be that this system is involved in the control of association responses by the frontal cortex. Consistent with this is their finding that strychnine abolished the effects of basal ganglia stimulation. The possibility that our results for cortical association responses might be an

artifact of stimulus current spread to the basal ganglia was ruled out by undercutting the stimulated cortex: all effects of stimulation were eliminated.

Since strychnine appears to abolish most forms of postsynaptic inhibition and picrotoxin markedly reduces presynaptic inhibition (Eccles, 1964), the drug effects obtained in our experiment suggest that depression of cortical association responses following cortical stimulation may involve postsynaptic inhibition and the enhancement of primary responses may involve presynaptic inhibition. However the time course of the depression of association responses is strikingly parallel to the time course of presynaptic inhibition on primary afferent fibers of the spinal cord following comparable stimulation of the somatic-motor cortex (Andersen, Eccles, & Sears, 1964). In contrast to the effects described here, however, this type of presynaptic inhibition is maximal with stimulation of somatic sensory area I, and cannot be elicited by precruciate stimulation after ablation of somatic sensory area I. In any event, the diametrically opposed actions of strychnine and picrotoxin on the two cortical stimulation effects described here suggest that rather different neural mechanisms may be involved.

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Note

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Dissociation of movement initiation without dissociation of response choice¹

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The chemical (drug) state of 24 rats was changed between training and test performances in a T-maze discrimination task. This did not affect response choice (proportion of correct turns), or response execution (running time), but retarded movement initiation (start time). Thus the processes involved in response choice and movement initiation are not identical, and the movement initiation processes are the more susceptible to changes in S's chemical state.

Dissociation here refers to the lack of transfer of a trained response from one organismic (e.g., chemical) state to another. Overton (1964) found that a positional T-maze escape response trained in a (subanesthetic) barbiturate state failed to appear when S was tested in the normal, nondrug, state; nor was there any transfer to the drug state after training in the normal state. This suggests that the processes involved in correct response choice are impaired when S's drug state is altered. Employing nondiscriminative responses, Bindra, Nyman & Wise (1965) found that barbiturate-induced dissociation occurred only when the test performance required active movement; performance requiring immobility or the withholding of a response transferred well between the barbiturate and nondrug states. Bindra, Nyman, and Wise suggested the possibility that response choice and movement initiation involve separate processes and that they are subject to dissociation to different degrees.

One direct test of the above suggestion would consist in determining whether dissociation of movement initiation can occur without dissociation of response choice in one and the same experimental arrangement. The present experiment was aimed at answering this question.

Method

Twenty-four adult male rats were divided into two equal groups, a group trained in a phenobarbital state and tested in the nondrug state (PhS-NDS group) and a group for which these treatments were reversed (NDS-PhS group).

A wooden T-maze, with an electrifiable grid-floor was used for avoidance training. It was 6 in. wide and 4 in. high. Its center alley was 17 in. long and each of the two goal arms was 19 in. long. The initial 7 in. of the center alley served as a start box and the terminal 11 in. of each goal arm served as a goal box. Cue cards, consisting of vertical or horizontal .5-in.-wide black and white stripes, could be attached to the entrance door to each goal box. An electric shock generator-scrambler was connected to the grid-floor

and set to deliver a shock of .8 ma. The two goal boxes were made safe from shock by placing wooden platforms on the floor.

A photo-cell in the center alley, placed 6 in. from the start gate, was employed to measure response latency (i.e., the time elapsing between the raising of the start gate and the rat's passage across the photo-cell) and response time (i.e., time elapsing between the rat's passage across the photo-cell and its entry into the goal box).

The PhS was produced, as required, by an intraperitoneal injection of 30 mg/kg of sodium phenobarbital, injected 15 min. before the daily trials.

After preliminary escape training, each S was trained on a schedule of one 10-trial session per day; the intertrial interval was about 1 min. The rat was placed in the start box facing backwards. About 2 sec. later the door was opened and simultaneously a 10-sec. delay timer was turned on. If S had not reached the open (correct) goal box within 10 sec., the shock was automatically turned on and it remained on until the response was completed. The cue cards were alternated from side to side according to the following two-day sequence, LRRLRLRLRL, RLRLRLRLRL. An error was recorded if the rat took the wrong turn and tried to push the (locked) door into the wrong goal box; the correction procedure was followed. For half the animals in each group the vertical stripes signified the open goal box, for the other half horizontal. The experiment was run on a schedule of six days per week.

When the rat reached the criterion of a minimum of eight avoidance responses in one session, the procedure was slightly altered. If the rat started the response (i.e., broke the photo-cell beam) but failed to complete the response within 10 sec., it was given only momentary "prompting" shocks whenever it became stationary until the response was completed. However, if the rat did not start the response within 10 sec. shock was applied throughout the remainder of the trial. This procedure was designed to minimize exposure to shock while insuring that a response choice would be made on every trial.

When an animal reached the criterion of a minimum of nine correct choices in one session (whether or not they were successful avoidance responses) on three consecutive training days, test sessions were begun. Test sessions were given in the "other" drug state, but apart from this the testing procedure was the same as in the later part of the training.

Results

Both groups, PhS-NDS and NDS-PhS, reached the criterion of acquisition in about the same mean number of training sessions (8.8 and 8.9 days, respectively). In other respects (e.g., number of "prompting" shocks given) too there were no noteworthy differences between the two groups.

Figure 1 presents the data for the four training sessions immediately preceding the change in drug state and for the four test sessions. In the transition from one drug state to the other there was only a slight decrease in the number of correct responses; the mean number of correct responses remained close to 9 out of 10. All rats clearly retained the discrimination following the change in drug state. Group means of the daily response latency (median of 10 daily trials) showed that the change in drug state resulted in a marked increase in response latency in both groups. Significance tests for correlated samples showed the increase to be significant in both groups (PhS-NDS: $t=2.62$, $p<.05$; NDS-PhS: $t=4.85$, $p<.001$). Twenty-two out of the 24 animals increased their median response latency from the last training sessions to the first test session. The corresponding increases in response times were not significant (PhS-NDS: $t=1.38$, $p>.10$; NDS-PhS: $t=1.18$, $p>.20$); the rather large increase seen in the curve for the PhS-NDS group was due to an erratic score (30 sec.) of one animal only.

Discussion

Under the conditions of the present experiment, the change in drug state produced no dissociation effect so far as the correct response choice was concerned but clearly increased start time. This supports the hypothesis that the processes involved in response choice and movement (response) initiation are not identical, and that

the movement-initiation processes are the more susceptible to changes in the drug state of the organism. The absence of an increase in running time could indicate that only movement initiation, not response execution, was impaired in the transition from one drug state to the other; but such a conclusion would have to be confirmed in an experiment without prompting shocks during test trials.

Whatever, neural impulses are required for movement initiation (see earlier discussion by Bindra, Nyman, & Wise, 1965), these impulses can undoubtedly be generated by noxious stimulation, for no impairment of movement initiation is evident when an escape response is used. Thus, in the avoidance situation, the movement-initiation impulses must be generated by the CS, and it is this ability of the CS that must be disrupted in the transition from one drug state to the other. Recent evidence from ablation experiments (e.g., Thompson, 1964; Vanderwolf, 1963, 1964) implicates the medial thalamus, the diffuse thalamic nuclei, and the frontal cortex in the initiation of anticipatory (i.e., made in response to CS rather than US) responses. Thus a key to the understanding of the dissociation of movement initiation may lie in the change in the neural events within these structures produced by an alteration of the organism's chemical state.

The dissociation of movement initiation can apparently be demonstrated with drugs other than the barbiturates (e.g., chlorpromazine: Otis, 1964), but the dissociation of discriminative response choice has so far been demonstrated only with barbiturates or related compounds. Some minimal amount of dissociation of response choice would have been expected in the present experiment on the basis of Overton's (1964) findings. As there are many procedural differences between Overton's study and the present one, the source of the apparent discrepancy is not immediately clear.

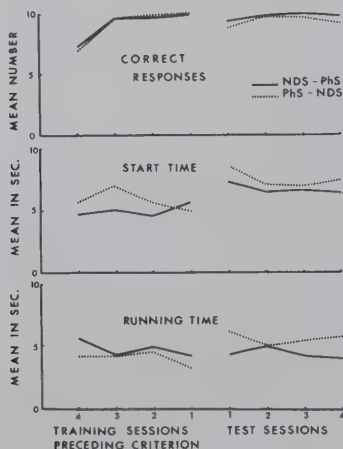


Fig. 1. Means of correct responses and start and running time scores for four pretest training sessions and four test sessions for the two groups.

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Note

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Perceptual factor: Quantity of food available and consummatory behavior in chickens

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The relationship between quantity of food available and quantity ingested was examined. Two groups of 12 chickens each were tested with feeders designed so that one type (large) visually presented more than twice the quantity of food as the other (small). The ease of obtaining the food was essentially the same for each type of feeder. No significant difference in consumption was established between the two groups, suggesting that availability of food may have been an important contaminating error in other studies.

The quantity of a stimulus available to an animal either as a reinforcer or incentive is often considered an important variable in a number of theoretical considerations in psychology. A report by Ross, Goldstein, & Kappel (1962) described a direct relationship between the size of a pile of grain presented to a hungry chicken and the amount eaten. Their research was in part instigated by a similar finding by Katz (1937) as part of his two-component (external-internal) determinants of a need system. The role of external stimuli or environmental factors in the development of feeding behavior in chickens has been reported by Shreck et al (1963).

However, another explanation of the Ross et al result seems possible. Ignoring contamination by the significant order effect and the small size of groups, it is possible that the smaller piles of food represent a more difficult feeding task than do the larger piles of food. Chickens tend to scatter their food and the smaller the pile the greater must be the effort required to obtain an adequate quantity of food. The larger the pile the greater will be the density of available food within a feeding area. Therefore, to more effectively test the proposed hypothesis, the ease of obtaining the food must be kept constant despite variations in the quantity of food presented.

Subjects

The Ss were 48 male Arbor Acre White Rock chicks, isolated within 48 hr. after hatching to prevent any possible effects of socialization of feeding behavior. Until 21 days of age, all birds had constant access to food and water available in kidney-shaped aluminum dishes bearing no resemblance to the test feeders. All birds were kept in light 24 hr. a day to prevent any deprivation periods that might be forced by darkness. At 20 days of age, the birds were weighed and assigned weight ranks from 1 to 48. The 12 heaviest and 12 lightest birds were discarded at this time. The remaining 24 birds were matched for weight, and one bird from each matched pair was assigned either to large or small feeder test conditions.

Apparatus

Two feeders built of plywood (sides and bottoms) and Plexiglas (top and front) were designed to visually present different areas of food to the chicken but still maintain equal access and ease of obtaining of food on each peck (Fig. 1). Depth of the food from the opening was constant, with only the front surface side of the feeder varying. The large feeder contained 180 gm of food while the small feeder contained 75 gm. The food used was commercially available chick starter mash.

Procedure

When Ss were 16 days old, their regular feed dishes were replaced for 30 min. by an intermediate size feeder containing 120¹ gm of food. This practice was repeated for the following four days giving each bird a total of 2-1/2 hr. in which to become adapted to the characteristics of the test feeders. No deprivation preceded these test periods. All Ss (48) were pre-adapted and the division into experimental and maintenance groups followed the last adaptation session.

On the 21st day of age, the experimental cycle was started. This procedure consisted of 12 hr. of food deprivation, 15 min. of exposure to food in the test feeder, and then 23-3/4 hr. of ad lib feeding from the kidney-shaped dish. Twelve hours of food deprivation then followed reestablishing the cycle once again. The same food was employed in the test condition as was used in ad lib feeding; water was always present. This cycle was repeated 11 times. During the deprivation period care was taken to remove all traces of food from the cage surroundings and the water dishes. The very little spillage that occurred during test feeding was collected and returned to the feeder in order to determine the amount consumed.



Fig. 1. Test and training feeders varying size of food pile while holding accessibility constant.

Results

The mean amount consumed per bird for the large and small feeder groups over the 11 test trials is presented in Fig. 2. The overall analysis indicates no significant effect as a function of the size of feeder presented to the chickens. The only significant effect is that of trials ($F=5.56$, 10 df., $p<.01$). A subsequent orthogonal breakdown of the trial effect demonstrates a significant linear trend ($F=27.4$, 1, 22 df, $p<.01$).

The difference in consumption between the large and small feeder groups is, initially, in the predicted direction; however, it fails to meet the required level

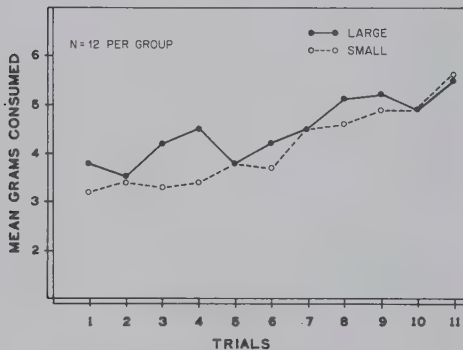


Fig. 2. Mean amount consumed for large and small feeder conditions for eleven trials.

of significance. A comparison of the first trial difference ($t=1.52$ for 11 df) and the difference between the means of the first four trials ($t=1.61$ for 11 df) which, on inspection of the curves, appear to be the intervals of greatest difference, fails in test of significance. Further, the rate of change in consumption for the large feeder groups is not significantly different from the rate of change in consumption for the small feeder group. This is true (linear trend analysis) even for the first four trials where the mean differences between the two groups are largest ($F=.678$).

Discussion

Inspection of the raw data indicates rather large variability among chickens in the quantity of food they ingest. The overlap in amount consumed in the two feeder groups is considerable. The only significant effect is the increased amount consumed over Trial 1 through 11, which is easily accounted for in terms of increased size (age) of the chicken. It would appear from this study that the significant results reported by Ross et al could be attributed to ease of eating rather than size of the stimulus.

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Note

1. This size feeder was used based upon previous pilot study results.

Runway behavior of the gray rat snake with food and water reinforcement¹

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Two groups of gray rat snakes were given training in an enclosed alleyway. Both groups were maintained on a seven day food and water deprivation schedule. Ss of the experimental group were run to food and water reinforcement. Control Ss were run in the same manner except that there was no reinforcement in the goal box. All Ss received one trial every seven days unless they were moulting. Measures of latency and running time produced diverging curves for the experimental and control groups, due principally to the increase in both measures for the latter group.

Two studies have been most frequently cited as laboratory investigations of behavioral modification in snakes. One (Kellogg & Pomeroy, 1936) concerned the ability of water snakes to escape from a relatively cold water temperature in a water T-maze into a goal box having a higher water and air temperature. The results showed that individual snakes varied greatly in their performance, assumed to be due in part to ecdysis, but that the progress of the entire group was characterized by a drop in time and errors.

The second study (Wolfe & Brown, 1940) employed a dry multiple T-maze at a high temperature. The snakes were supposed to escape from the maze into a shaded pan of water. The snakes failed to show evidence of learning, perhaps due to the extremely high temperature used (48° - 55° C), although this was not the conclusion reached by the investigators. Wolfe and Brown further attempted to use electric shock as a noxious stimulus, but again failed to demonstrate learning.

The present investigation attempted to demonstrate runway acquisition to positive reinforcement in contrast to the above experiments studying learning as a function of escape conditioning. Preliminary studies from this laboratory indicated that gray rat snakes would drink water readily following deprivation, although attempts to train them to run down a runway to water reinforcement failed when they were tested in an apparatus having a transparent lid. These snakes were feeding regularly under laboratory conditions so it was decided to run them to food and water reinforcement in a runway having an opaque cover.

Method

Ss of the experiment were eight gray rat snakes, *Elaphe obsoleta spiloides*, measuring 91.4-152.4 cm at the beginning of the experiment. Ss were divided into two groups, a control group (C) and an experimental group (E), of four Ss. A S in the C group was discarded prior to actual training because of irregular eating

habits. This S was the smallest snake and its size, in addition to the fact that it had been more recently captured, may have contributed to its lower food requirements. All the remaining Ss were over 122.0 cm in length. Ss were maintained on one or more small chickens per week and were observed to eat regularly and readily. They were housed in individual aquariums under conditions of controlled humidity (40%) and temperature (25.5° C).

Ss were run in a 182.9 cm wooden alleyway having a start box and goal box each 30.5 cm in length. The internal height and width of the alleyway were 15.2 and 14.0 cm respectively. The start box and runway were each covered by separate hinged wooden lids. The goal box was covered by a hinged transparent lid of plastic. Each of the partitions separating the runway from the goal box and start box had a 4.4 cm diameter hole centered in the partition. On the runway side of each partition a photo cell and light source were mounted so that the passage of the S through the hole in the partition operated relays controlling two chronometers. The chronometers were wired to give separate goal box latency and runway running time. The exterior of the apparatus was painted flat black, but the interior was unfinished.

Ss were placed on a seven day food and water deprivation schedule four weeks prior to the beginning of the experiment. Ss were then given one trial every seven days unless they were in some state of ecdysis. Under such conditions the trial was postponed until the next trial would normally occur. Ss in the E group were run to food and water reinforcement. A young chicken and a small bowl of water were placed at the end of the goal box on each trial. The chicken was secured by a silk cord made into a slip knot around the chicken's leg. The cord passed through a small hole in the wall of the goal box. After the snake had tripped the second photocell relay the chicken was released by pulling the cord. If S did not leave the start box within 30 min. a latency and running time of 30 min. was arbitrarily assigned. This procedure was necessary on two occasions: on the first trial of one E S; and on the last trial of one C S. Each S was allowed up to 60 min. following the release of the chicken to eat and drink. Feeding usually took place immediately but some chickens were larger and more aggressive and thus delayed feeding. There were two instances in which a S did not eat in the apparatus. These occurred on the first trial of two Ss.

Ss in the C group were begun four weeks after the E group when it became apparent that the E Ss demonstrated an initial decrease in latency and running time followed by only a relatively lower although variable response level. Ss in the C group were run in the same manner as the E group except that food and water were not located in the goal box. Following each trial the C group Ss were given access to food and water in the home tank for an hour.

Results and Discussion

The E Ss were run over a 14 week period, and the C Ss over a 10 week period. The experiment was terminated at this time because of an inability to obtain chickens from hatcheries in Northern Florida and Southern Georgia during the late summer, a situation which had not been anticipated. As indicated above Ss were not run when moulting and at the end of the experiment 12 trials had been completed by two E Ss, and 11 trials by the remaining 2 E Ss. All Ss in the C group had completed eight trials. For convenience in presenting the data the two Ss in the E group receiving only 11 trials were assigned the same scores on the 12th trial as they obtained on the 11th. The data for the two groups were then "Vincentized" by determining the running means of every seven and three trials for the E and C groups, respectively. Thus trials 1-7, 2-8, 3-9, ..., 6-12 for the E group, and trials 1-3, 2-4, 3-5, ..., 6-8 for the C group appear for latency and running time measures in Fig. 1. It may be seen from Fig. 1 that the log mean latencies and running time for the E group are initially low, and remain so during the course of the experiment. The Ss of the C group, however, show a continuing increase in both latency and running time. The response time measures, i.e., the sum of the latency and running time scores, are not plotted because of the similarity of the E and C group latency and running time curves. The initial difference between the E and C groups in running time are due to the first two trials. Since the E group Ss initiated their trials in the apparatus when

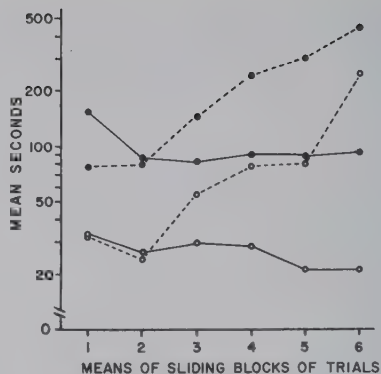


Fig. 1. Log mean latencies (open circles) and running times (solid circles) for experimental (solid lines) and control (broken lines) groups.

the odor and other stimuli from the presence of snakes and chickens were not so pronounced, this initial difference is assumed to be a procedural artifact. Nevertheless the lack of "acquisition" in the E group and the essential "extinction" of the C group is perhaps the most interesting outcome of the experiment. Such behavior would not necessarily be considered unusual in a rat study, but snakes have a well-earned reputation for being refractory Ss only intermittently responsive to appetitional deprivation. The cliché concerning the distinction between performance and learning being a function of motivation appears to apply to the snake as well as to other organisms.

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Note

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Effects of the pitch and duration of tones on EEG desynchronization¹

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EEG waves were recorded while Ss were exposed to tones of four frequencies, equated for subjective loudness and lasting for 1, 2, or 3 sec. Mean duration of desynchronization was a U-shaped function of acoustic frequency and an increasing linear function of stimulus duration.

Both musical practice and everyday experience suggest that arousal may be affected by auditory pitch. There are grounds for suspecting that, in music, higher notes produce a more "exciting" or "emotional" effect (Berlyne 1960, pp. 172-173), but pitch is usually confounded with other variables, such as timbre, loudness, direction of change in pitch, and relative frequency of occurrence.

The present experiment was designed to compare effects of four tones of equal loudness but differing frequencies on one index of arousal or component of the orientation reaction, namely the duration of EEG desynchronization. A second objective was to ascertain how the duration of desynchronization varies with the duration of a tone.

Method

EEG was recorded by means of a Grass Model V Polygraph from an electrode on the left occipital area with an electrode clipped to the left ear lobe as ground. Apart from the differences noted, the recording procedures, criteria for discarding Ss, and scoring techniques were the same as those used in a previous experiment on effects of visual complexity (Berlyne & McDonnell, 1965).

Tones of four frequencies—200, 400, 800 and 1600 cps—were used. These represent the same note (between G and G[#]) in each of four consecutive octaves. They were presented through a pair of earphones and came from three sinusoidal-tone generators through an electronic switch controlled by a Hunter timer.

The intensities of the tones were set to give a reading of 70 db with weighting B on a General Radio Type 1555-A Sound-Survey Meter. Weighting B, prescribed by the American Standard Association, is designed (Peterson & Gross, 1963) to follow the Fletcher-Munson (Fletcher & Munson, 1933) equal-loudness contour at 70 phons. A comparison of the ASA B-weighting curve with the curve supplied by Fletcher and Munson reveals that both are horizontal at 70 db between 400 and 1600 cps. At 200 cps, the former prescribes an intensity of 72 db whereas the latter has an ordinate of 74 db. So, if anything, the ASA curve undercorrects for reduced sensitivity to the 200-cycle tone, which should therefore be equal or slightly lower in loudness in comparison with the three higher tones.

Each of the four frequencies was presented three times at each of three durations—1 sec., 2 sec., and 3 sec. Three random sequences of 36 tones were drawn up with the restriction that each successive set of 12 (to be referred to as a "phase") contained each combination of a frequency and a duration once. These three sequences and their inverses were used with approximately equal numbers of Ss.

The Ss were all male undergraduates attending elementary summer-session courses in psychology. The data from 49 Ss were left for analysis, after 23 had been discarded for having alpha waves more than 95% or less than 50% of the time or because interference made the tracings unclear.

S was seated in a comfortable chair in a darkened room and was instructed to keep his eyes closed. After each tone, E waited until alpha waves had reappeared before manually triggering the Hunter timer in order to bring on the next tone. The interstimulus interval varied between 3 sec. and 20 sec., apart from a few trials on which it was between 2 and 3 min.

Results

The duration of desynchronization could not be measured for 60 out of the 1,764 stimulus presentations, usually because the pen went out of range. Missing data were therefore inserted, and degrees of freedom adjusted, according to the procedures prescribed by Anderson (1946).

The mean desynchronization durations of primary interest are displayed in Figs. 1 and 2. The quadratic

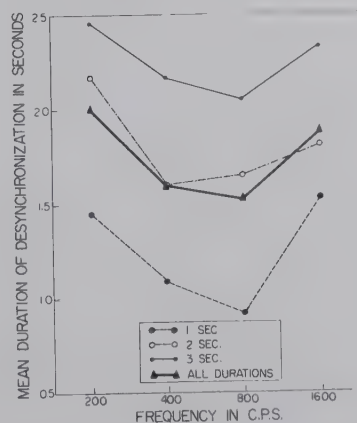


Fig. 1. Mean desynchronization duration as a function of acoustic frequency.

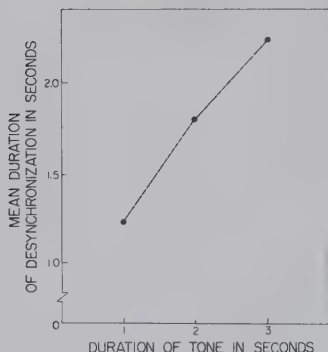


Fig. 2. Mean desynchronization duration as a function of stimulus duration.

component of the differences due to frequency is significant ($F=38.03$, $df=1/1445$, $p<.001$), but the linear component and the deviation from quadratic trend are not. The linear component of the differences due to stimulus duration is significant ($F=181.02$, $df=1/1445$, $p<.001$), but the deviation from linearity is not.

Discussion

The mean desynchronization durations fell a little short of the stimulus durations (see Fig. 2). Alpha waves often resumed before the tone ended or appeared in brief bursts while the tone was on. It is interesting that there was a rectilinear relation between desynchronization and stimulus duration.

Various hypotheses might be advanced to explain the U-shaped function that connected desynchronization duration with acoustic frequency. The hypothesis that the intensification of the orientation reaction as the extremes of the frequency range are approached may reflect differences in relative frequency of occurrence, and thus in novelty, can be rejected. The lower half of the frequency range used in the present experiment includes the compass of the human voice. The first formant in closed vowels pronounced by male speakers is commonly around 200 cps (Peterson, 1951), while the highest note that a soprano can normally reach is around 1,000 cps.

Two other kinds of hypothesis might account for the effect. First, a S might, either through natural selection

or through learning, be more susceptible to arousal by high-pitched and low-pitched tones than by tones of intermediate pitch because the former are more frequently associated with events of biological importance (squeals of pain, thuds from collisions, etc.). Another possibility is that the U-shaped curve in Fig. 1 represents the resultant of two opposite trends. One would be a tendency (inherited, learned, or due to differential novelty) for the magnitude of the orientation reaction to increase with pitch. The other would be a tendency, due to conditioned affective responses, for the orientation reaction to become more intense as the frequency with which a particular pitch occurs in human speech increases.

It would seem from our data that the special emotional effect of a high note in music, e.g., at the climactic point of a musical phrase, is unlikely to be due to an effect of pitch as such, since most music belongs to the sector of the frequency spectrum within which pitch and arousal value were inversely related. This effect is more likely to depend on the relative novelty or surprisingness of a note that is higher than any heard during the last few bars. This suggestion is corroborated by the fact that relatively novel or surprising notes within the frequency band of the notes that have just been heard, i.e., chromatic notes, seem to be at least as arousing.

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Notes

1. This investigation was supported by Research Grant MH-06324 from the National Institute of Mental Health, United States Public Health Service, and by Grant No. 70 from the Ontario Mental Health Foundation.
2. The authors are indebted to Sharon Lazare and Paul McDonnell, who carried out pilot experiments and helped in the analysis of the data.

Effects of satiation on performance as a function of stimulant and depressant drugs¹

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An experiment was done to test the effects of repetition as a function of drug treatment (dextedrine and seconal) on a variety of performance measures. Three criterion measures were employed (semantic differential scales, paired-associate learning and an arithmetic task). Support for the hypothesis that under stimulant drug conditions satiation effects would be more pronounced as compared with sedative drug conditions received partial support on the paired-associate task only. Satiation effects were found on the arithmetic task but these were unrelated to the drug administered. The semantic differential scales did not yield consistent results for either repetition or drug.

Pyke (1964) found that for Ss tested under dextedrine, repetition led to a reduction in meaning while seconal drug conditions produced an increment in meaning after continuous repetition. In the study by Pyke (1964) as well as experiments by other researchers (Floyd, 1962; Jakobovits, 1962; Jakobovits & Lambert, 1961; Lambert & Jakobovits, 1960) the semantic differential has been employed as the criterion variable. More recent research has indicated that the use of the semantic differential to measure meaning changes following repetition may be undesirable due to the possible confounding effects of regression (Schulz, Weaver, & Radke, 1965; Yelen & Schulz, 1963). This problem is circumvented in the present study through the use of performance measures not subject to regression effects. Paired-associate learning and an arithmetic task, as well as the semantic differential form the criterion variables for this study. These tasks were selected because they have been found to be sensitive to satiation effects (Jakobovits & Lambert, 1962; Kanungo, 1962).

The purpose of this study was to test the generality of the results obtained by Pyke (1964) using performance measures as the criterion indices. It was predicted that following repetition the performance of Ss tested under a stimulant drug condition would deteriorate, while Ss tested under a depressant drug condition would improve or show no change after repetition.

Method

The sample was composed of 32 university students. Two lists of paired-associates (PA), each consisting of 10 pairs, were prepared. Following the procedure of Kanungo, Lambert, & Mauer (1962), nonsense syllables and words served as stimulus and response members respectively. The sample was divided into two matched groups on the basis of performance on PA List 1, with the procedure for presentation modelled after

that of Kanungo et al (1962). Approximately one week later, Ss were tested under the drug condition using a double-blind procedure. One group received 15 mg of dextedrine and the other 125 mg of sodium seconal. Approximately 75 min. after drug administration, all response members of PA List 11 were rated on three semantic differential scales (Kanungo et al, 1962). Immediately following the initial ratings, five of the response items were subjected to the repetition treatment. Ss were required to repeat each word for three 15 sec. intervals. After repetition, all Ss rerated the original 10 response members of PA List 11. Immediately following final ratings, PA List 11 was presented for learning.

The second task was modelled after that of Jakobovits & Lambert (1962) except that the computation involved is a multiplication rather than addition problem. Twenty-four problems were used, 12 constituting the experimental series (the digit repeated was involved in the problem) and the remainder the control series (the digit repeated was not involved in the problem). The problems themselves and their order of presentation was identical to that of Jakobovits & Lambert (1962).

Results

Winer's (1962, p. 324) model for a three-way analysis of variance with repeated measures was employed to analyze the semantic differential data which was scored using the Lambert & Jakobovits (1960) procedure. The predicted effect is a Drug by Rating by Repetition interaction. That is, words subjected to the repetition should show reductions in meaning on final ratings as compared with initial ratings for dextedrine Ss. The same words should show increments for seconal Ss. The only significant effect obtained with this analysis was for Repetition. Repeated words were rated more extremely than unrepeated words on both initial and final testing. Thus, no evidence was found for a satiation effect for either drug group on semantic differential scales.

On PA List 11, the trials to criterion and the error scores were calculated separately for the repeated and nonrepeated response members. Two-way analyses of variance were carried out on these data following Winer's (1962) model where one variable is correlated. The F-ratio for repetition was the only significant effect found ($F=9.18$; $df=1/30$; $p<.01$ for trials and $F=4.73$; $df=1/30$; $p<.05$ for errors). Contrary to previous findings by Kanungo et al (1962), fewer errors were made with repeated concepts and these concepts required fewer trials to learn. There was some suggestion that intralist competition was greater for nonrepeated concepts but this could not be tested directly. For the multi-

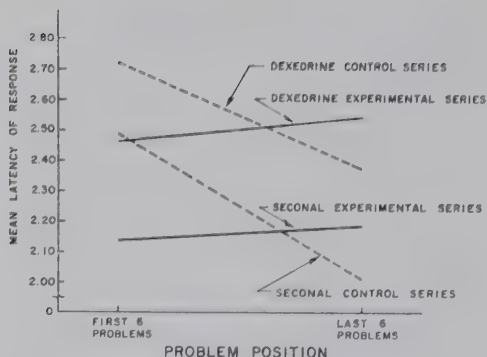


Fig. 1. Mean latencies of drug groups on the arithmetic task.

plication task latencies were summed separately for the first and last six problems of both the experimental and control series. A three-way analysis of variance was performed on these data (Winer, 1962). A significant Repetition ($F=12.00$; $df=1/29$; $p<.001$) effect was found. These results are presented in Fig. 1. Both drug groups showed facilitation on the experimental series for the first six problems and increased latencies for the experimental series on the last six problems as compared with the control series.

Discussion

In general, this experiment adds support to the rapidly accumulating evidence that semantic scales are inappropriate as criterion measures of the effects of repetition. However, with reference to the effects of repetition on performance measures the picture is somewhat more encouraging. There is clear support for the deleterious effect of large amounts of repetition on response latencies to perform a problem involving a concept previously subjected to repetition treatment. Similarly, there is some suggestion that had the PA items been matched for

intralist competition, repetition might have led to poorer performance, at least for the dexedrine drug group.

The specific prediction under test in this experiment that repetition would have differential effects as a function of drug treatment received little direct support. Results on the PA learning task do lend some support to the prediction but the differences are not significant. It is possible that drug effects were wearing off by the time the arithmetic task was presented or that these groups differed in their motor speed skills.

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Note

1. This research was supported by grant No. APA-148 from the National Research Council of Canada. An extended report of this study may be obtained without charge from Neil McK. Agnew, Psychological Research Center, 1214 College Drive, Saskatoon, Saskatchewan.

Developmental effects of the A^Y substitution on mouse activity level¹

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Short-term activity level was tested with inbred mice of four genotypes in an open-field apparatus. These data supplement earlier results for long-term exploratory activity using the same genetic stocks. The results indicate that the effects of A^Y in suppressing locomotor activity are not restricted to long-term experimentation nor to a specific apparatus in mature (125 day old) Ss. Different results are found at each of the three age levels studied, however. The interpretation utilizes indirect evidence from earlier strain-difference studies and is open to experimental challenge. It is also noted that components of sexual and agonistic behavior patterns may provide stable phenotypes for behavior-genetic investigation.

This paper reports a partial replication and extension of an earlier experiment (Hawkins, 1965). In that study the stocks of mice used here were tested in a large (1 x 4 x 4 ft.) multiple-unit maze over a long (165-min.) test period. It was found that A^Y , which has numerous pleiotropic structural effects, also affects the amount of exploratory activity exhibited by 125 day old C57BL/6J mice. Of interest here was whether or not similar differences in performance would be found with a different activity measure and with a shorter testing period. Also of interest was the course of behavioral development over time.

Subjects

The Ss were C57BL/6J mice maintained with forced heterozygosis at the agouti locus. One-half of the animals were black (genotype aa); the rest were yellow (genotype $A^Y a$). The Jackson Laboratory stock to which they can be traced were N = 22, F = 11. Independent groups of 10 animals, of each sex, from each color variety, were run at three age levels: 35 (+ or - 3), 80 (+ or - 11), and 125 (+ or - 9) days. In this study, all groups included siblings produced by matings of A^Y bearing parents of both sexes.

Apparatus

A Lehigh Valley Electronics, automatically recording, open-field activity apparatus was used. This device consists of a metal drum, painted flat-black, which is 16 in. high and 18 in. in diameter. Six infra-red beams cross each other at the base. Three parallel beams 4 in. apart lie along one plane; three equivalent beams are at right-angles to them. A plywood insert was used as the running surface. Thus, a 16 unit grid was formed across an homogenous field. Each bank of parallel beams has its own counter. The data counts used were the sum of both counter totals for each S.

Procedure

Ss were weaned at 30 days and housed by experimental groups (5 to a cage) in wire mesh cages 8 x 10 x 12 in. Custodial and laboratory conditions were as described previously (Hawkins, 1965). In testing, each animal was released in the open-field and given one 15-min. trial. Ss were run under normal room illumination during the light portion of the usual 12 hr. dark/light cycle.

Results

An analysis of variance gave as significant sources, locus, sex, age, locus by age, and sex by age effects. Locus by sex and locus by sex by age variance was non-significant at the .05 confidence level. Figure 1 graphs the performance of each genotype.

The t tests ($df=38$, 2 tail) within each sex and within each color variety between ages gave the following results: (1) 35 vs 80 day comparisons; all tests ($t=1.86$ or less) nonsignificant. (2) 80 vs 125 day comparisons; males ($t=2.95$, $p < .01$), aa ($t=4.92$, $p < .001$), females and $A^Y a$ ($t=2.02$ or less) non-significant. (3) 35 vs 125 day comparisons; males ($t=5.06$, $p < .001$), aa ($t=5.10$, $p < .001$), females and $A^Y a$ ($t=1.46$ or less) non-significant.

The t tests ($df=18$, 2 tail) between sexes and between color varieties within age levels gave these results: (1) 35 day old groups, male vs female ($t=3.78$, $p < .01$).

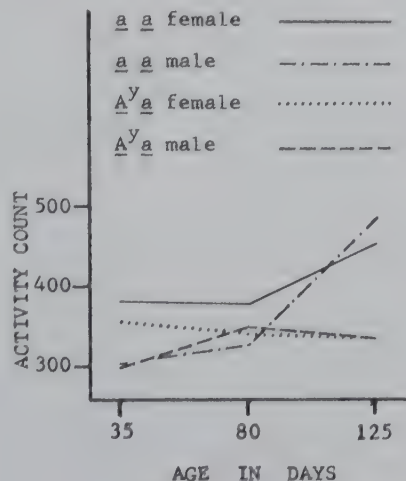


Fig. 1. Performance of each genotype at each age level.

- (2) 125 day old groups, *aa* vs *A^ya* ($t=6.38, p<.001$).
 (3) All other comparisons non-significant ($t=1.12$ or less).

Discussion

This study indicates that the yellow lethal gene *A^y* produces the same sort of behavioral differences on a short term open-field activity test, that were previously found with long-term exploratory activity. That is, C57BL/6J-*A^ya* mice exhibit much less activity than do their siblings homozygous for *a*. To a certain extent then, this study confirms and extends the results found earlier. However, it also restricts some of the conclusions which may be drawn. The replication of results applies only to the 125 day old animals.

As in the previous study, locus by sex interaction is nonsignificant. The significant interactions that do appear are primarily attributable to changes in performance by *aa* and by male Ss at successive age levels. Significant sex differences are found at 35 days while agouti locus differences are absent. At 80 days there are no significant differences attributable to either sex or locus. Finally, at 125 days, locus differences are found but not those attributable to sex.

Two hypotheses can be advanced with regard to such data. First, it can be postulated that the *aa* genetic constitution predisposes animals of this strain to high locomotor activity when fully mature. Alternatively, the action of *A^y* through the period of maturation may suppress the activity level which such animals would otherwise have attained.

An argument based on reevaluation of previous strain difference studies (by post hoc consideration of the agouti locus constitution) could be used in support of the first position. For example, in Thompson's classic study of exploratory activity (1953), there is a preponderance of strains homozygous for *a* high inactivity as opposed to those further down the list. Also, the first major change in his tabulated values of *p* differences comes with a strain homozygous for *A^w* (*white bellied agouti*). His least active strain, however, is homozygous for *a* and most investigators would probably contend that multiple differences in the total gene complement between strains is most likely the basis for such results.

With regard to the hypothesis that *A^y* acts as a suppressor, there are several indirect sources of support. First, Thiessen (1965) in his review of spontaneous activity notes: "...relative strain differences tend to be maintained, with the order of activity from high to low, C57, DBA, and C3H." In those experiments which Thiessen reviewed that involved strictly locomotor activity, there are no reversals between C57 and DBA Ss. Since both of these strains are homozygous for *a*, it is apparent that agouti locus constitution is not a necessary variable in activity

difference experiments. Next, when stovepipe emergence activity is considered, four experiments (Lindzey et al, 1960, 1963) have shown a complete reversal with DBA Ss showing shorter latency than C57 Ss. It thus appears that each strain represents a stable behavioral phenotype but that strain reversals may be found with different kinds of activity measures.

This conclusion is supported when one considers measures of the components of sex behavior. McGill & Blight (1963) report on 14 measures of sex behavior using C57BL/6J and DBA/2J Ss. There are 10 measures in which C57 vs DBA comparisons are significant. Eight of these can be viewed as activity measures. In all eight, the C57 Ss are the more active strain. One of the components not considered here as an activity measure is "percentage of bites." While none of the C57 males bit the females at ejaculation, twenty percent of the DBA males did. This, too, might prove to be a stable phenotype. In ecologically oriented free-breeding tests, Calhoun (1956) found that DBA Ss were less successful in reproduction than were C57 Ss due, in part, to more frequent and more intense fighting among themselves—extending even to male attacks on females.

In summary, locomotor activity and stovepipe emergence appear to be stable behavioral phenotypes when comparisons are made between strains. The data of this experiment suggest that *A^y* acts as a suppressor of locomotor activity in C57BL/6J mice at maturity. There is some evidence that certain components of sexual and agonistic patterns might also provide stable phenotypes when considered as activity measures. The effects of *A^y* in such contexts are unknown.

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Note

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Effect of presence of an imprinted object on response of ducklings in an open field and when exposed to a fear stimulus¹

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This study was designed to determine whether ducklings would show evidence of attachment to a previously "imprinted" object when they were placed in an open field at 14 days of age. It was found that they did show attachment, spending considerably more time in the center of the field when the object was there than when it was absent. It was also found that when a fear object was placed in the field, half the ducklings stayed close to the imprinted object despite the fact that it meant being closer to the fear object than any duckling would tolerate in the absence of the imprinted object.

Much interest in the imprinting phenomenon stems from the fact that according to the original theoretical discussion of imprinting (Lorenz, 1937), it represents a situation in which an attachment formed during a brief critical period of development has a widespread influence on subsequent behavior. However, as Moltz (1963) has pointed out, experimental study of imprinting has been confined largely to the following-response in precocial birds during the first few days of life. Thus, we have little experimental evidence on the generality of imprinting effects across stimulus situations or on responses other than neonatal following. Recently, Klopfer (1965) has suggested that it may be possible that the imprinting experience itself has very much more limited effect than is commonly believed, with the preferences resulting from imprinting limited to specific situations. He was led to suggest this partially on the basis of his findings that under certain conditions chicks imprinted on plain models will subsequently prefer brightly-colored models to the plain ones.

The present experiment was designed to determine the extent to which the imprinting attachment shown by ducklings (in terms of close and persistent following of an inanimate object) during the first few days of life would still be manifested at 14 days of age, in a different situation, where the object was stationary rather than moving. Further, the experiment was designed so that it might be possible to assess the influence of the imprinted object on responses other than those directed toward that object, per se.

Method

The Ss were 10 Peking ducks (*Anas platyrhynchos*) hatched in a forced-air incubator in the laboratory at Wayne State. When not being tested, they were housed in individual cages with ad lib food and water. The cages provided visual isolation from one another, but

not auditory isolation.

The imprinting apparatus was a circular wooden alley, 1.6 m in diameter, .6 m high, with a .3 m track around its perimeter. Six 150-w incandescent lamps were mounted above the alley to provide light and warmth. The imprinted object was a green Styrofoam rectangle, 10 cm x 15 cm suspended from a metal arm which carried it around the alley. A motor drove the arm so that it moved at a constant speed of 23 cm/sec.

The "open field" was a 1.2 m x 1.2 m x .6 m high enclosure made of masonite with the floor marked into nine .4 m x .4 m squares, numbered consecutively from upper left to lower right. A number of common objects were placed in the open field: a coil of rope in area 1; a man's cap in 3; a soup can in 6; and shoebox in 7. Two 150-w incandescent bulbs were suspended over the enclosure.

The imprinting procedure was to remove each S from the incubator within 7-14 hr. after hatching, then expose him to the moving rectangle for 30 min. On the second day of life, another 30-min. imprinting trial was given, and on days 3, 4, and 5, there were imprinting periods of 15 min. per day. On these last three sessions, the following-response was scored by E's activating a timer whenever S was either walking behind the object within a distance of 30 cm or standing on any side of it within a distance of 15 cm. At 14 days of age, each S was placed in the open field for two 20-min. sessions with 10 min. in between. Initial placement was in the lower right-hand corner of the field, area 9.

During the last 5 min. of each open field session, the fear-stimulus, a "raggedy Ann" doll, 25 cm high, was suspended from a wooden pole in the upper right-hand corner (area 3) of the open field. (Preliminary testing indicated that the doll reliably elicited vigorous escape responses and loud peeping from two-week-old ducklings.)

Half the birds (group PA) had the "imprinted" green rectangle present in the center of the open field (area 5) on the first session and absent from the field of the second, whereas for the other half (group AP) the order of presence and absence was reversed. These groups had been matched in terms of mean following scores on days 3, 4, and 5 combined.

Responses in the open field were recorded on data sheets that allowed E to trace the course of Ss' movements throughout the entire session. Times of entrance to and exit from each area were also recorded

and occurrences of calling, pecking, defecation, etc. were noted.

Results and Discussion

All of the birds showed a high level of following during the initial imprinting series, ranging from a low of 2265 out of a possible 2700 sec. of following over three days to a high of a flat 2700. In the open field, nine of the 10 ducklings showed evidence of attachment to the now stationary rectangle. The ducklings' behavior in the open field when the rectangle was absent consisted primarily of a continuous rapid pacing and loud peeping, or of standing in one of the corners of the field. When the rectangle was present, however, they spent a considerable portion of time in area 5, the center of the field, sitting or standing close to the rectangle. There were essentially no responses that could be detected as directed toward any of the other objects. The attachment to the imprinted object is reflected in Table 1, which shows the mean number of seconds spent in area 5 and the mean number of lines crossed under each condition. An analysis of variance for correlated measure revealed that there was significantly more time spent in area 5 in the presence of the object than in its absence ($F=21.53$, $df=1/8$, $p<.001$), with no significant effect of the AP versus PA order, and no significant interaction. The pattern of scores of line-crossing frequencies was essentially bimodal and extremely variable between Ss, ranging from 4 to 132 lines crossed. Neither a 2 by 2 analysis of variance nor a number of non-parametric tests yielded evidence of a significant difference in line-crossing frequency, although there was significantly greater variability when the object was present than when it was absent ($F=4.03$, $df=2/9$, $p<.05$). Three birds in the PA group did show a dramatic increase in activity when the object was absent (including one that spent relatively little time, 140 sec., with the object when it was present), but one showed a similar difference in the other direction.

Table 1. Mean time in seconds (T) in area 5 and mean number of lines crossed (LC)

Object condition	Open field				Fear			
	1st order		2nd order		1st order		2nd order	
	T	LC	T	LC	T	LC	T	LC
Present	451	12.8	527	24.2	127	5.4	118	9.2
Absent	40	24.4	142	68.2	0	3.0	0	11.6

The response to the fear stimulus when the imprinted object was absent was perfectly consistent and clear cut. All ducklings moved rapidly away from the fear stimulus to one of the corners of the field. None even so much as entered area 5, or any other area adjacent to the locus of the fear stimulus in 3. With the object present, there appeared to be conflicting tendencies between maximizing distance from the fear stimulus on the one hand, and maintaining contact with the object on the other. Thus, every duckling entered area 5 when the fear stimulus was presented, but half the Ss then withdrew rapidly into one of the corners. The other half spent most of the 5-min. period next to the object in area 5, even though it meant being closer to the fear stimulus than any bird would tolerate even momentarily in the absence of the object. The existence of so many "0" scores precluded parametric analysis of the data, but a chi-square test of frequency of staying in area 5 yielded a significant difference between conditions ($p=.016$ by Fisher's exact p). There was no indication of an order effect or significant interaction. Thus, the ducklings' attachment to the object as it stood motionless in the open field was strong enough to overcome the tendency to avoid the fear object for a significant number of birds, and compelling enough to elicit at least initial approach from all the birds.

These results provide evidence for extension of the early following-response attachment in several ways. It was extended from the alley to the open field, from a moving object to a completely motionless one, from 5 day-old ducklings to 14 day-old ones, and from following to standing or sitting in proximity. Each of these extensions is admittedly a relatively modest one, but the attachment was strong enough to significantly counteract avoidance of a fear stimulus, and on the whole, the results provide some support for the general conception of imprinting as having a strong influence beyond the neonatal following response. Certainly, further exploration along various dimensions of change is needed in order to determine the nature and extent of the influence.

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Note

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Conditional discrimination learning in rats¹

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Criterion on a conditional discrimination was attained by 20 of 24 rats. No significant differences were found between Ss trained with and without correction and between Ss trained with one dimension black and white as opposed to horizontal and vertical striations. Test trials following criterion revealed the response-eliciting cues to be stimulus compounds, the simplest stimulus arrangements permitting problem solution.

Conditional discrimination learning has been demonstrated on several occasions in the rat (e.g., Lashley, 1938; North, Maller, & Hughes, 1958). In addition, North et al presented data showing that problem solution was based on the acquisition of approach responses to stimulus compounds rather than to stimulus configurations. However, to date there are almost no data relating the rate of conditional discrimination learning to variables known to affect other types of discriminative learning in rats. The present study was directed towards this task; the effects of training procedure (correction vs. noncorrection) and stimulus dimension (the pairing of forms with vertical and horizontal striations as opposed to black and white) were evaluated in a 2 by 2 factorial design. In addition, test trials, identical to those employed by North et al, were administered following acquisition to determine the response-eliciting cue.

Subjects

The Ss were 24 naive male hooded rats, approximately 90 to 120 days old at the beginning of training. Ss were placed on a 23-hr. feeding schedule and maintained at 90% of their ad-lib weight.

Apparatus

A Wisconsin General Test Apparatus, modified for the rat, was employed. The stimuli were wooden circles and triangles onto which black and white or horizontally and vertically striped, cardboard cutouts could be attached.

Procedure

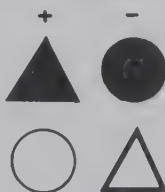
Twelve Ss were trained under a correction schedule and 12 Ss under a noncorrection schedule. Six Ss within each group were trained with black and white forms and six with striped forms.

Figure 1 presents two sample problems and their corresponding test-trial stimuli. In the problem shown in the upper lefthand portion of Fig. 1, the triangle was positive and circle negative when both figures were black, while the reverse was true when both figures were white. In this problem form is the dimension differentiating stimuli within a pair, and brightness is the conditional or between-pair differentiating dimension. A similar problem can be constructed for the

SAMPLE PROBLEMS

1) FORM PLUS BRIGHTNESS

TRAINING



TEST



2) FORM PLUS STRIPES

TRAINING



TEST



Fig. 1. Two sample training problems and their corresponding test stimuli.

two striped subgroups by substitution of horizontal and vertical stripes for black and white, as shown on the lower left-hand portion of Fig. 1. Within each of the four subgroups, three Ss were trained with form as the within-pair dimension and brightness or stripes as the between-pair or conditional dimension, and vice versa for the three remaining Ss.

The orders for presentation of stimulus pairs over trials and positioning of the correct stimulus were determined by Gellermann series. All Ss received 25 trials per day, five days per week, until reaching a criterion of 20 of 25 responses correct on two consecutive days, or until 800 trials had been presented.

On the day following attainment of criterion, 10 additional training trials and then 20 test trials were given. The righthand side of Fig. 1 shows the test-trial stimuli for the two sample problems. Test-trial stimuli differed from training stimuli in that the positive stimulus from one pair of stimuli was combined with the negative stimulus from the second, and conversely. In this manner, two new configurations were arranged while maintaining the previously positive and negative

compounds. The expectation is for chance performance given response tendencies to configurations and better than chance performance given responses to stimulus compounds.

Results

All but four animals achieved criterion within 800 trials, and the distribution of failures was not systematic. The two striped subgroups had one failure each, and the black-white correction subgroup had two failures. A 2 by 2 factorial analysis of variance, performed on trials to criterion, revealed no significant main effects or interaction.

The mean number of trials to criterion for the 20 learners was 354, and the mean level of performance during the two criterial sessions was better than 87%.

Of the 20 Ss reaching criterion, 13 made fewer than two errors, and only one S made as many as five errors. The obtained mean of 1.4 errors was significantly less than 10 errors, the expected number had Ss been responding to configurations during the training phase ($t = 24.6$, $df = 19$, $p < .001$).

Discussion

The results of the present study, although showing conditional discrimination learning in rats to be unaffected by correction or stimulus variables, are not without interest when compared with the results obtained by North et al. For not only did a greater proportion of the present Ss attain criterion, 83% versus 41% ($z = 2.8$, $p < .01$), but the number of trials to criterion for these Ss was also fewer by over 400. An examination of procedural factors yielded two probable sources of facilitation: (a) training procedure; and (b) apparatus. As for training procedure, North et al treated each of the two stimulus pairs constituting the conditional discrimination as separate problems. That is, training was accomplished by having Ss reach criterion on the

first pair and then on the second pair, with this sequence being repeated four times. Note, however, that until Ss learn to respond to both the within-pair and between-pair cues as a unitary pattern of stimulation, they are in fact undergoing a short series of successive reversals, an experimental situation known to produce negative transfer at least over the early reversals. The random alternation of the two pairs of stimuli over trials precludes this source of interference. Use of the WGTA may also have produced a facilitative effect by eliminating the considerable emotionality associated with the Lashley Jumping Stand, especially when the problem is difficult and the errors and punishment are numerous.

As for the test-trial data, the finding of approach responses to stimulus compounds confirmed the earlier results of North et al and supported Spence's (1952) conception of the stimulus in discrimination learning. Spence hypothesized that rats may learn approach responses to components, compounds, or transverse patterns (configurations), these responses being to the simplest stimulus arrangements permitting problem solution—compounds in the present experiment.

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Note

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Prompted vs. trial-and-error 3-trial object discrimination learning by monkeys¹

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Four relatively naive monkeys were given extended 3-trial object discrimination training under either conventional trial-and-error or prompting procedures. Whether Ss were prompted on only the first trial of each problem or on all 3 trials of alternate problems, their performance on test trials was equivalent to that of Ss receiving conventional training.

Test-naive monkeys given conventional trial-and-error discrimination training, especially on problems with few trials-per-problem and hence many chance-determined first trials, necessarily make a high proportion of nonrewarded responses which could conceivably lower motivation and result in the early and persistent adoption of response patterns which are incompatible with problem solution. It is conceivable that a prompt (i.e., an established cue which indicates the baited object) would insure a greater percentage of rewarded responses during training and thereby produce relatively better learning. The primary purpose of this study was to test this possibility by comparing the *relative* performance of monkeys given either conventional trial-and-error training or prompted training on object discrimination problems.

Of secondary interest was the *absolute* levels of performance of monkeys given 3 trials-per-problem (t/p). Levine et al (1959) trained naive monkeys under either 3 t/p or 12 t/p, and on the basis of those and other re-examined data they suggested that, at least within the range of 3 to 12 t/p, the acquisition of a learning set was a function of the number of training trials regardless of the way in which the trials were distributed among problems. In his recent review of the effect of t/p on discrimination learning Miles agreed with this generalization. However, the literature reveals a disconcerting lack of consensus regarding the absolute level of performance around this apparently practical lower limit of 3 t/p. With monkeys, for example, both Miller et al (1955), using 3 t/p, and Davis (1953), using 4 t/p, obtained poorer performance than that reported by Levine et al, and Hayes (1953) has even reported no interproblem improvement in one chimpanzee trained under 2 t/p.

PHASE 1

Method

Four 4-year-old female rhesus monkeys served as Ss. Approximately 3 mo. prior to this study each S was tested on two 36-trial object discrimination problems (see Fletcher et al, 1965).

All testing took place in a WGTA with a modified test tray made completely from opaque white acrylic plastic and containing two channels in which slid 4 x 4 in. white plastic bases. In their forward position the bases butted

against the front edge and covered two foodwells 10 in. apart. The tray's front edge, which was 2-1/2 in. high and angled 45 degrees from horizontal, contained two 1-in. jewelled amber lights (prompts) centered directly in front of each foodwell. Multidimensional junk objects were attached to the bases, and S was required to push the object (not the base) back to expose a foodwell.

Although all Ss were familiar with the apparatus and testing procedures, each was required to demonstrate retention of an appropriate response in the presence of the prompt. On each of 36 trials per session two identical gray blocks were presented with the prompt lighted in front of the baited foodwell. Each S was tested until a criterion of 30 correct responses in any session was reached. Raisin rewards and non-correction procedures were used during this and subsequent testing.

Sixteen test sessions followed, and each session consisted of 16, 3-trial object discrimination problems presented under either of two procedures. For two randomly selected Ss the prompt (light) was lighted in front of the correct object, and S responded in the presence of the prompt, on Trial 1 only of each problem; the remaining two trials continued without the prompting. For the other two Ss conventional trial-and-error procedures (no prompting) were used for all three trials. Within each session rewarded position was balanced with respect to first trials and the total 48-trial session. Because they were part of the laboratory's breeding program and not always available, Ss averaged only 2.7 sessions per week.

Results and Discussion

The data presented in the left panel of Fig. 1 reveal first that the prompt was moderately effective in controlling correct responses on Trial 1. However, subsequent intraproblem performance was essentially identical following either Trial 1 procedure. Thus, despite the greater number of rewarded Trial 1 responses, this type of prompted training resulted in learning which was no different from that which followed conventional trial-and-error training.

The absolute level of performance of all Ss on Trials 2 and 3 was much lower than that reported by other investigators even though these Ss had previously demonstrated excellent intraproblem learning following the first six trials on two initial 36-trial object discrimination problems (88% following six prompted trials, 95% following six conventional trials; Fletcher et al, 1965). Nevertheless, the percent of correct responses on both Trial 2 and Trial 3 for all four Ss combined was significantly above chance ($t=4.298$ and 7.561 , respectively; $df=3$; $p<.025$).

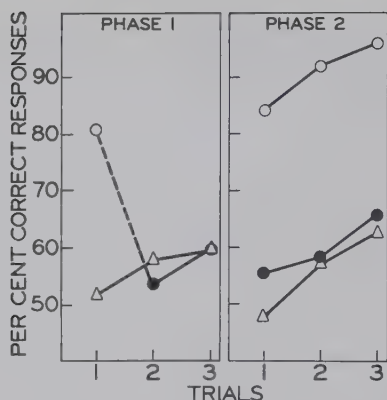


Fig. 1. Intraproblem performance under conventional trial-and-error training (triangles), in the presence of the prompt (open circles), or on test trials following prompting (closed circles).

PHASE 2

Problem

Trial 1 prompting cannot, of course, provide intraproblem training, i.e., the adoption of any 3-trial sequence or strategy, and Ss obviously did not utilize the minimum information provided on Trial 1. An attempt was made in this phase, therefore, to facilitate intraproblem learning by training an appropriate 3-trial sequence (win-stay). This was accomplished by prompting all three trials of alternate problems.

Method

This phase continued with a procedural modification for only the two Ss which had previously been prompted on Trial 1. On all odd-numbered problems of each session the prompt was lighted in front of the correct object for all three trials. The remaining eight even-numbered problems per session were presented under conventional trial-and-error procedures as were all 16 problems for the two Ss given conventional training previously. Fifteen such sessions, averaging 3.7 sessions per week, were given.

Results and Discussion

The data in the right panel of Fig. 1 demonstrate again that the prompt was moderately effective in eliciting a correct response on Trial 1. Subsequent prompted performance on Trials 2 and 3, however, was considerably better, in fact characteristic of test-sophisticated monkeys. Thus throughout the entire phase Ss' performance on 50% of the problems was excellent. Yet despite their excellent intraproblem performance (on prompted problems) Ss demonstrated (on alternate test problems) a level of learning which was virtually identical to that obtained from Ss trained under conventional trial-and-error procedures.

In general, the test performance of all four Ss remained low but significantly above chance (for Trials 2 and 3, respectively, $t=9.106$ and 13.865 ; $df=3$; $p<.005$). In fact, the performance of all four Ss was so homogeneous that the range of scores on Trials 2 and 3 for both phases averaged only 5 percentage points.

GENERAL DISCUSSION

It is interesting to note that during the prompted problems of Phase 2 Ss were in fact responding almost completely according to a "win-stay" strategy. It is obvious, however, that training on only this half of a "win-stay, lose-shift" learning-set strategy had neither a beneficial nor a detrimental effect on learning.

Thus, with respect to relative performance following prompted or trial-and-error training, these data convincingly indicate no differential effect of training procedure. Positive effects of guidance, or prompting, on discrimination performance of monkeys have, of course, been demonstrated. Cochrane & Davis (1961), for example, reported a facilitative effect of "forced choice" pretraining with young monkeys, and Fletcher & Takemura (1965) found better concept discrimination learning by sophisticated monkeys following one form of prompting. Differences in subjects, problems, and specific forms of prompting vitiate any meaningful comparisons, of existing research, and the critical variables underlying the facilitating effects of prompting remain unspecified.

The absolute level of performance of Ss given conventional training was surprisingly low during these almost 1500 trials. This poor performance may be due to the fact that Ss were not available daily and were consequently learning under an unfortunately distributed training schedule. Or these data may reflect an actual lower limit of monkeys' performance on 3-trial object discrimination problems. As mentioned before, the literature is discouragingly inconsistent with regard to performance around 3 t/p, and this fact alone indicates a need for parametric investigations of the relative efficiency of various t/p on discrimination learning.

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Note

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The immediate and long-term effect on runway performance of reversing ethanol and dextrose conditions

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Shifting from alcohol to dextrose or dextrose to alcohol conditions produced the following results: At the reversal point, shifts in either condition resulted in no performance decrement. After the reversal, running speed increased if shifted from alcohol to dextrose, and decreased if shifted from dextrose to alcohol.

Studies dealing with the effects of shifting from placebo to alcohol or from alcohol to placebo conditions have resulted in apparent discrepancies. On the one hand, Denenberg, Pawlowski, & Zarrow (1961) report that shifting from placebo to alcohol did not result in a response decrement; whereas Barry & Miller (1962), Miller & Miles (1936), and Nelson & Wollen (1965) report a response decrement after the shift to alcohol. On the other hand, Nelson & Wollen (1965) also report that shifting from alcohol to placebo results in a greater response decrement than shifting from placebo to alcohol.

These contradictory findings and their explanations are difficult to interpret due to: Lack of non-reversed control groups (Nelson & Wollen, 1965); inadequate control of injected alcohol (Denenberg et al, 1961); and use of alcohol solutions whose concentrations not only differ, but were potentially too weak to reflect the alcohol's effects. The study reported below is a further attempt to determine the effects of shifting from alcohol to placebo, and vice versa, by controlling the weaknesses reported above.

METHOD

Subjects

The Ss were 40 naive, male, hooded rats from the Washington State University colony. The Ss, which ranged from 90-116 days old at the beginning of deprivation, were maintained on a 23-hr. food and water deprivation schedule.

Apparatus

The apparatus used was a straight alley 60 in. long, divided into a 12-in. start box (SB), a 36-in. alley, and a 12-in. goal box (GB). Inside alley dimensions were 3.5 in. wide and 4.7 in. high. The apparatus was painted flat black throughout, and the entire runway was covered by clear Plexiglas. Two guillotine doors separated the SB from the alley. The door nearest the SB was transparent, whereas the one nearest the alley was opaque. An opaque door separated the GB from the runway.

Pretraining

Pretraining consisted of (1) handling each animal 3 min. daily from the fifth to the fourteenth day of deprivation; (2) feeding each animal 10 97 mg Noyes reward pellets immediately prior to his daily ad lib feeding from the tenth to the fourteenth day of deprivation; (3) injecting each animal with ethanol (1.5 cc of a 30% by volume ethanol and distilled water solution per 100 gm of body weight) from Day 10 to Day 14 of deprivation; and (4) allowing Ss, in groups of 3, to run freely in the apparatus for an hour per day from Days 11 to 13 of deprivation, and alone for 15 min. on Day 14.

Training

During training each S was weighed immediately before running, and depending upon the group to which he belonged was injected with 1.5 cc/100 gm of either a 30% ethanol and water solution or a caloric-equivalent (54.86 gm/100 ml of water) dextrose solution. Both solutions were heated to 101° before being given. Fluid administered was by stomach loading, using a Baxter K-31 Infant Feeding Tube with syringe.

The training phase consisted of 45 trials per S, 5 the first day and 10 on each of the 4 successive days. The procedure for each trial was as follows. The S was taken from a waiting cage and placed in the start box. The opaque door was opened as soon as the S oriented towards it. Exactly 1 sec. later, the second (transparent) door was raised automatically. When the S reached the GB, the GB door was lowered to prevent retracing. Following the consumption of one 97 mg Noyes pellet the animal was placed in a waiting cage for an intertrial interval of 70 sec., following which another trial was given.

The response measure used was the time required to run from the interception of a light-beam 6 in. from the SB until the S intercepted a second beam, 24 in. farther down the alley. Following each day's 10 trials, Ss were given the opposite solution from that given before they were run.

Post-shift

During the post-shift phase, which included 10 trials per day for 5 days, half of the Ss in each group (alcohol and dextrose) were changed to the opposite condition, whereas the other half of each group continued to receive the same solution. Each group was designated by two letters indicating the pre- and post-shift condition re-

spectively, i.e., AA, AD, DA, and DD. The study was run in 5 replications, with each replication consisting of 2 Ss in each of the 4 groups. Within each replication, Ss were assigned so that the mean weights for the 4 groups would be approximately equal.

RESULTS AND DISCUSSION

Figure 1 presents the running speed (ft./sec.) data for Days 1 and 5 which were analyzed by means of a design in which experimental conditions were a between factor and days a within factor. Since the analysis revealed a significant days by drugs interaction ($F=11.46$, $df=1/38$, $p<.005$) analyses were conducted on individual days. There was a significant difference between the two groups on Day 1 ($F=23.38$, $df=1/38$, $p<.001$), but not on Day 5 ($F<1$). This initial superiority of the alcohol group has been found by other investigators (Barry, Wagner, & Miller, 1962, and Denenberg et al, 1961) but was not expected in the present study since pretraining was instituted to reduce the initial fear of the apparatus. In spite of the pretraining, the results suggest that the adaptation was insufficient to reduce the Ss' fear and, consequently, the initial superior performance of the alcohol Ss was probably due to the fear-reducing properties of alcohol (Barry et al, 1962).

Analysis of the data from Days 5 and 6 indicate

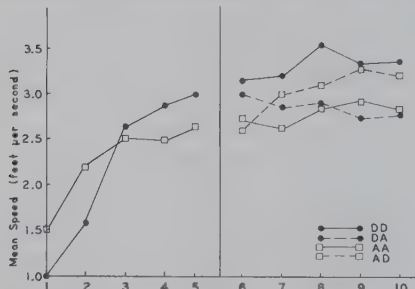


Fig. 1. Mean running speeds as a function of experimental conditions.

that shifting from alcohol to dextrose or vice versa produced no change in running speed ($F<1$). These data suggest that with adaptation to the apparatus and alcohol, there is no immediate effect of reversing the experimental conditions.

If one analyzes the post-reversal data for Groups DA and AD, then an effect of reversing conditions is apparent. Analysis of the running speed data for Days 6 and 10 indicated a significant days by drugs interaction ($F=4.17$, $df=3/36$, $p<.025$). In addition, Group AD's running speed increased significantly from Day 6 to Day 10 ($F=13.65$, $df=1/9$, $p<.005$), but the decline in Group DA's speed did not reach significance ($F=3.25$, $df=1/9$, $p>.10$). Therefore, it appears as though the long-term effect of reversing conditions is an increase in running speed if shifted from alcohol to dextrose, but no effect if shifted from dextrose to alcohol. However, the significant difference between Groups DA and DD on Days 9 and 10 ($t=2.18$, $df=1/9$, $p<.05$) suggests that shifts from dextrose to alcohol eventually result in a performance decrement.

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Note

1. Now at the Psychophysiology Lab., VA Hospital, American Lake, Washington 98493.

Secondary reinforcing properties of informative and non-informative stimuli¹

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BERT FORRIN, SCARBOROUGH COLLEGE, UNIVERSITY OF TORONTO

This study compared the secondary reinforcing properties of two cues distinguished on the basis of their prior significance in a brightness discrimination problem: a cue discriminative for reinforcement but not present in the goal region (a non-redundant predictor of reward) and a cue present in the goal region but irrelevant to the acquisition of the required discrimination (a redundant predictor or reward). The findings suggest that both cues were equally effective in reinforcing a simple position habit.

A revision of the traditional Hullian conception of secondary reinforcement (Hull, 1943) has recently been proposed by Egger & Miller (1962, 1963). They assert that the potency of a conditioned reinforcer is influenced not solely by its proximity to primary reward but by its informative properties. Given a sequence of stimuli which invariably precede a reinforcing event by a brief (but unspecified) span of time, only the first stimulus is a non-redundant predictor of reward-to-come. Later cues in the sequence add no new information relative to the occurrence of reinforcement. Egger and Miller contend that, by virtue of its information value, the first stimulus, despite the greater delay of primary reinforcement, is most likely to acquire secondary reward value. Their experimental findings were consistent with this position. The present investigation serves to provide a further test of the Egger-Miller information hypothesis.

Method

The Ss were 32 experimentally naive, male albino rats of the Sprague-Dawley strain, approximately 110 days old. Ss were run in two squads (replications) of 16 animals each. A two-stage procedure was employed.

1. Brightness discrimination training.—All Ss, 23 hr. hungry, received 10 trials per day in the modified Grice maze shown in Fig. 1. Half were trained on the grey-black (black positive) problem illustrated; the remainder, on a grey-white (white positive) problem. In the former case, the antechamber leading to the positive goal box and its entrance and exit doors were flat black; the goal chamber was flat white. In the latter, the positive discriminative cue was white and the positive goal box, black. The remainder of the maze, except for the clear Plexiglas start-box door, was painted flat mid-grey. All doors were of the swinging type with stops to prevent retracing. A correct choice was reinforced by a pellet of Gaines' Dog Meal. Criterion performance was defined as at least nine correct responses on each of two successive days. Each S re-

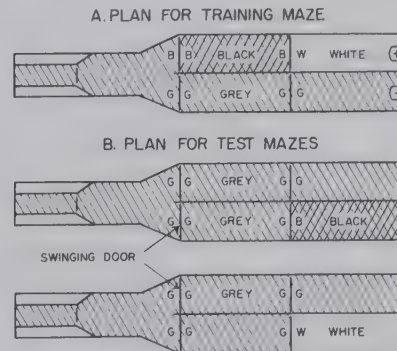


Fig. 1. Sample floor plans for the brightness discrimination training and the position habit test mazes. (.1 in. = 1 in.) The brightness for each side of a swinging door is given by the letters B (black), G (grey), and W (white). For the training maze indicated, the critical alley in the upper test maze terminates in the prior discriminative cue; the critical alley in the lower test maze terminates in the prior goal-box cue.

ceived two additional post-criterion days of training before being shifted to the position problem.

2. Position habit training.—Training was conducted in a slightly altered version of the discrimination apparatus. The form of the maze was unchanged but, with the exception of one goal box, the entire maze was painted mid-grey. For one-half of the Ss, the brightness of one goal box (designated the critical cue) was that of the previous discriminative cue; for the remainder, the brightness was that of the goal chamber during discrimination training. Since the effect of the critical cue upon position preference was at issue, its location was fixed for each S throughout training. The brightness of the critical cue (black or white) and its location (left or right) were completely counterbalanced over Ss.

All Ss were 23 hr. hungry when trained. A non-correction procedure was employed. No food reinforcement was offered but Ss were permitted to remain in the chosen goal box for 15 sec. Training was conducted on two successive days. On the first, Ss were initially given one free trial followed by one forced trial to the side not chosen. All subsequent trials were free. Ss received eight additional trials on the first day and 10 on the second.

Results

Mean per cent choice of the critical alley is plotted as a function of successive blocks of two trials in Fig. 2. With Trials 1 and 2 omitted, the data were analyzed in terms of a Conditions by Replications by Days design.

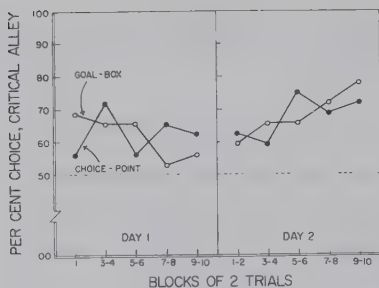


Fig. 2. Per cent choice of the critical alley as a function of blocks of two trials for the two experimental groups. Data for the second trial on Day 1 (forced) are omitted.

No main or interaction effects proved statistically significant. Preference for the alley terminating in the prior choice-point cue did not differ significantly from preference for the alley terminating in the prior goal-box cue— $F < 1$, $df=1/28$. Nor was there a significant change in preference over conditions from the first to the second day of training— $F=1.141$, $df=1/28$. A more fine grain analysis in terms of Conditions by Replications by Blocks within Days yielded only one statistically significant effect: preference for the critical side increased linearly over blocks on Day 2— $F=7.480$, $df=4/112$, $p < .01$. Though, as noted, variation in the prior role of the critical cue had no significant effect upon performance, the mean per cent runs to the critical side (65.97% for the choice-point group, 64.58% for the goal-box group) significantly exceeded the a priori chance base (50%) in each condition— $t=2.733$, $df=15$, $p < .02$ and $t=3.121$, $df=15$, $p < .01$, respectively.

Discussion

The test for secondary reinforcement was a stringent one involving the capacity of the critical cues to facilitate the learning of a new position habit in the absence of primary reinforcement. In addition, insofar as the critical cues were not present at the choice-point in the test maze, their effect is to be attributed not to their response-eliciting properties but to their reinforcing properties. The choice of critical alley with frequency greater than that expected by chance would, therefore, seem to establish the acquired reward value

of both the prior choice-point cue and the prior goal-box cue.

There are several grounds for caution in the unqualified acceptance of the latter conclusion. It is possible that position preference was influenced by aversive properties conditioned to the grey (formerly negative) goal chamber rather than by the acquired reward value of the critical cues. Or, the effective determinant of choice behavior may have been the change in brightness associated with the critical alley. Further, the evidence for the anticipated increase in preference for the critical side over training is ambiguous.

These limitations aside, if the occurrence of secondary reinforcement may be granted, it is apparent that the magnitude of the reinforcing effect did not differ between choice-point and goal-box cues. Consistent with the views of Egger and Miller, no gradient effect was noted. Though in greater temporal proximity to food reinforcement during brightness discrimination training, the goal-box cue did not acquire a greater reinforcing capacity. But, its considerable conceptual appeal notwithstanding, the Egger-Miller (1962) hypothesis that "a redundant predictor of primary reinforcement should not acquire secondary reinforcement strength" was not substantiated by the present data. Both critical cues were equally reliable predictors of primary reward but the goal-box cue was completely redundant. So could and did predict the location of primary reinforcement from the choice-point cue alone. Yet this difference in information value did not conduce to a difference in acquired reward value.

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Note

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Rat vocalization to shock with and without a CS¹

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Rat vocalization to electric shock was studied using a classical conditioning procedure for one group and presenting only the UCS to a second group. Ss given CS-UCS pairings vocalized significantly less to the UCS than Ss given only the UCS. Results were discussed and predicted from an information-preparation framework. Unexpected gradual UCR curves were obtained but no vocalization to the CS occurred.

One of the most striking and reliable behavioral observations of animals subjected to painful stimulation is the occurrence of repeated distress vocalizations during stimulation. This is especially common in the rat. The occurrence of such reliable responses provide the investigator with opportunities to identify the controlling variables of behavior and to discover generalized laws of conditioning using either operant or classical conditioning techniques.

The research reported here uses a classical conditioning procedure and deals with rat vocalizations to electric shock (UCS) but with emphasis on the unconditional response (UCR) instead of the typical emphasis on the conditioned response (CR). More specifically we are concerned with the number of vocalizations to electric shock when preceded by a warning stimulus (CS) in comparison with vocalizations when no CS is used. While vocalization to the UCS under these different conditions was our primary concern, we were, of course, also interested in the acquisition of vocalizations to the CS.

The theoretical frame of reference leading to our emphasis on the UCR instead of the CR is that of Perkins (1955). These theoretical statements diverge from traditional learning theory in that they state a CS paired with an aversive UCS does not necessarily acquire aversive properties. For Perkins, emphasis is on the informational value of the CS which allows the S to prepare for the receipt of stimulation either aversive or attractive. This preparation based on information provided by the CS is said to minimize the painfulness of aversive stimuli or maximize the attractiveness of appetitive stimuli. Recent evidence supporting the information-preparation notions in both aversive and appetitive situations has been published (Lockhard, 1963; Perkins, Lewis, & Seyman, 1963; Prokasy, 1965).

This study employs two groups and uses number of vocalizations to the UCS as the dependent variable. Group I Ss were given 36 paired CS-UCS trials while Group II Ss were given 36 trials with the UCS alone. Assuming the number of vocalizations to the UCS to

be an indicator of its aversiveness, it was predicted Group I would vocalize less frequently to the shock than Group II, since the former group could presumably prepare for the receipt of shock and thus minimize its aversiveness.

Method

The Ss were 22 naive hooded rats, one-half males, and one-half females, 90 to 121 days of age at the beginning of training. There were 10 Ss in the UCS group and 12 Ss in the CS-UCS group. The uneven N occurred as a result of correcting an initial male-female imbalance. However, one S was discarded from the UCS group for failure to vocalize resulting in an N of 21.

The apparatus was a clear Plexiglas compartment 9 in. long, 6 in. wide, and 7-1/2 in. deep with a grid floor of stainless steel rods. A 6 watt bulb located on the side panel served as a CS. The UCS was scrambled shock of .28 milliamps emitted by a Lehigh Valley Constant Current source. This low milliamp reading was used since pilot studies indicated all Ss vocalized at this level without ceiling effects. It should be noted that this level of shock is only slightly above the squeal threshold reported by Littman, Stevens & Whittier (1964). Group I was given 36 CS-UCS pairings with an intertrial interval of 1 min. using a delayed conditioning technique. The CS came on 3 sec. before the 2 sec. UCS and both terminated together. Group II was given 36 UCS presentations with all other conditions the same as the first group. A microphone was centered in the roof of the apparatus and connected to a tape recorder. Vocalizations were recorded at 7-1/2 in./sec. and played back and counted manually at 3-3/4 in./sec.

Results

As seen in Fig. 1 the vocalization curves between the

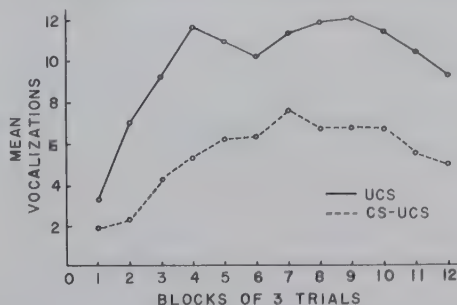


Fig. 1. Mean vocalization to the UCS in blocks of 3 trials for Ss given CS-UCS pairings or UCS alone.

groups separate early and remain apart over the 36 training trials. While the initial differences during the first trial blocks are small, the curves begin to diverge early in training and appear to asymptote at the same rate. The predicted fewer number of vocalizations for the CS-UCS group in contrast to the group receiving the UCS alone was confirmed. However, quite unexpected was the appearance of gradual UCR acquisition curves for both groups.

Also unexpected was the total lack of vocalization to the CS for Group I. Perhaps more trials or training sessions are necessary to elicit vocalizations to the CS. No differences in vocalization occurred between males and females.

Statistical analyses of the reliability of the above observations were performed using a mixed design with the experimental conditions of Groups I and II as the between variable and blocks of six trials (Trials 1-24) as the within variable. The analysis for differences in vocalizations between the groups was significant, $F=4.85$, $df=1/19$, $p<.05$. Thus confirming the predicted observation that the CS-UCS group vocalized less to shock than the UCS group. While the trial blocks analysis also attained a rigorous significance level, $F=42.00$, $df=3/57$, $p<.005$, the interaction between groups and trial blocks did not, $F=1.97$, $df=3/57$. These latter findings support the unexpected observation that UCR acquisition curves existed and that they did not interact with the experimental conditions.

Discussion

Assuming that frequency of vocalization reflects the aversiveness of the UCS, the finding that Ss vocalize less when given a warning signal (CS) preceding the UCS tends to support the information-preparation theoretical statements of Perkins (1955). Presumably responses made to the CS, considered preparatory in nature, minimize the aversiveness of the UCS and reduce the number of distress vocalizations. While taped recordings during the CS period did not indicate vocalizations to the CS, observations of behavior during this period indicated the Ss were inactive but tended to assume certain postural responses. Following Lockard's suggestions (1963) there are several ways in which shock aversiveness can be reduced: shock avoidance, current reduction, reduction of arcing, decreased current density. Since a constant current scrambled shock source was used in the present study, shock avoidance and current reduction are unlikely candidates. However,

and in agreement with Lockard, certain systematic postural responses, such as firmly gripping the grid bars with all four paws following CS onset, could have reduced current density by increasing contact area. Also, the arcing, characteristic of high voltage constant current sources, may have been minimized by the adoption of these postural responses. It should be noted, however, that no systematic postural differences were observed during the UCS period between the two groups.

A final point not yet discussed is the gradual growth of the UCR curves for both groups. We are uncertain and puzzled as to their interpretation but two possibilities can be considered: increases in arousal or drive with training, and superstitious operant vocalization.

First, drive or arousal could have increased with successive shocks. It seems unlikely, however, that the attainment of asymptotic drive levels would require 24 training trials. Further, motivational variables are usually defined in terms of their independence from practice and are characterized by rapid rather than gradual build up. For example, in other situations such as conditioned fear, asymptotic levels have been attained in fewer trials (Goldstein, 1960).

Second, the possibility of superstitious operant vocalization should be considered. Since vocalization occurred only during the short two-second shock period a superstitious contingency between vocalization and shock termination could have been acquired. The gradually increasing vocalization curves tend to support this latter speculation.

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Note

1. This research was supported in part by USPHS Grant MH 08960-01A1 to the senior author.

Some effects of light flicker rate on the pigeon

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Four pigeons were trained to peck a key which was briefly illuminated every 0.64 sec., a fifth was trained to peck a dark key, and a sixth a constantly illuminated key. Two more were trained to peck a key successively illuminated with nine different rates of flicker, the time between light onsets for the nine different rates ranging from 0.22 sec. to 2.01 sec. When the birds were given generalization tests in extinction with these nine rates of flicker, they responded with key pecking rates proportional to the key flicker rates, except for two of the four trained at the median rate of flicker (onset every 0.64 sec.) and the bird trained to peck the dark key.

It is well known that stimulus characteristics such as intensity and frequency may be functionally related to respondent behavior without specific training. However, the role of such variables in controlling operant behavior is not clear (Hull, 1952; Blough, 1959; Henderson, 1957; Fox, 1964; Stebbins & Miller, 1964). In the current study, the effect of variations in the rate of a flickering key light on the rate of key pecking was investigated.

Subjects and Apparatus

Seven male white Carneaux pigeons and one male homing pigeon maintained throughout the experiment at 75% of their pre-experiment free-feeding weight were used. Nine different rates of flicker (S1-S9) varying only in interstimulus interval (0.22, 0.29, 0.33, 0.44, 0.64, 0.89, 1.01, 1.63, and 2.01 sec.) could be projected upon the response key in a standard experimental chamber. Experimental contingencies and recording were automatically controlled.

Procedures

Training sessions consisted of a series of 1 min. stimulus periods during which reinforcement (5 sec. access to grain) was available on a 2 min. VI schedule of reinforcement. During stimulus periods the house lights were off and the appropriate training stimulus was projected upon the key. Each stimulus period was separated from the next by a 2 sec. period during which the key was dark, the house lights were on, and responding was without consequence. For Birds 1-4 the training stimulus (S5) was the median rate of flicker (onset every 0.64 sec.), for Bird 5 the training stimulus was a constantly illuminated key, for Birds 6 and 7 all nine stimuli were successively presented in an irregular order during training, and for Bird 8 the training stimulus was a continually dark key. For Bird 7 the procedure was modified in early sessions to insure that he received the same number of reinforcements in the presence of each stimulus. Training sessions were continued for each bird until response rates appeared stable from session to session.

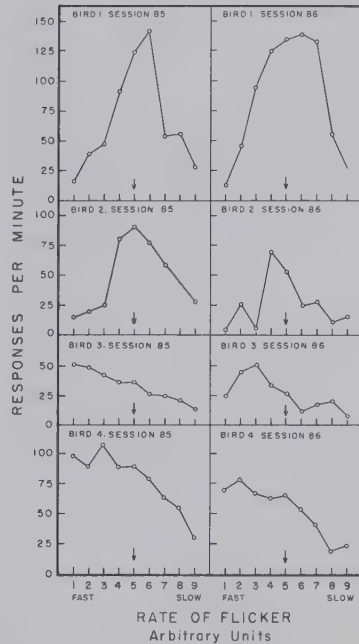


Fig. 1. Response rates during test sessions for four birds. The small arrows indicate the training stimulus.

Test sessions in extinction were given at the completion of training. During test sessions a different one of the nine stimuli was projected upon the key during each successive stimulus period. The order of presentations was irregular. Each test session was preceded by a brief period of reinforced responding under training conditions.

Results

Figure 1 shows the extinction gradients obtained from Birds 1, 2, 3, and 4. The curves from Birds 1 and 2 are fairly typical light flicker generalization gradients (Sloane, 1964), resembling gradients obtained from single animals for other stimulus dimensions. The curves from Birds 3 and 4 are not characteristic generalization gradients, the response rates being higher with high rates of flicker. Bird 3 does show a peak displaced towards S5 from the most rapid rate of flicker.

Extinction gradients for the remaining birds are presented in Fig. 2 and 3. After training with the constantly illuminated key Bird 5 responded most rapidly in the presence of faster rates of flicker. Conversely, after training with the dark key Bird 8

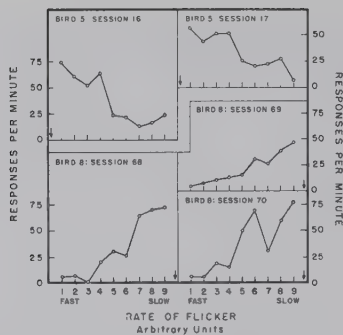


Fig. 2. Response rates during test sessions for two birds. The small arrows indicate the training stimulus.

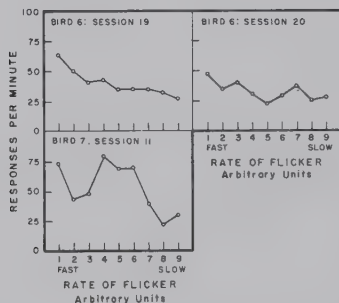


Fig. 3. Response rates during test sessions for two birds.

responded most rapidly in the presence of the slower rates of flicker. Birds 6 and 7, after training with all nine rates of flicker, responded most rapidly in the presence of faster rates of flicker. This "preference" appeared from earliest training when reinforcement was available in the presence of all flicker rates; in Fig. 4 the rates for those birds in the presence of each stimulus during early sessions are presented.

Discussion

The reasons for this preferential responding are not clear. Further study in which the flicker was

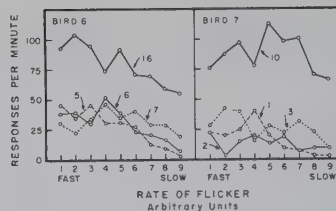


Fig. 4. Response rates during early training sessions for two birds.

generated by interspersing varying length "on" periods with brief and constant "off" periods suggested that total key illumination was not important. Studies in which the key remained illuminated in the brief inter-stimulus periods, as well as before and after the session, indicated that inadvertent discrimination learning, based upon unreinforced responding in the presence of a dark key during the interstimulus periods, was also not a factor (cf. Logan, 1954).

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Note

1. Most of this study was done while the author was at the Walter Reed Army Institute of Research on a Postdoctoral NIMH Fellowship, some while at the Johns Hopkins School of Hygiene and Public Health. The generous advice and facilities provided by Dr. Robert Clark, and the partial support obtained from General Research Support Grant H.55.6005 are gratefully acknowledged, as are the critical reading of the manuscript by Drs. Victor Laties and Sidney Bijou.

Effect of UCS intensity on the acquisition and extinction of a one-way avoidance response¹

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Forty one female albino rats received 50 trials of acquisition training in a one-way avoidance task with UCS (shock) intensities of 0.5, 1.5, 2.5, or 3.5 ma, and were subsequently extinguished. The 0.5 ma group made significantly fewer avoidance responses and had longer response latencies in acquisition and on the first extinction trial. The highest shock level produced significantly longer escape latencies on early trials but did not retard avoidance learning. These results are compared with those found using other avoidance tasks.

A previous experiment (Moyer & Korn, 1964) has shown that relatively intense shock interferes with the acquisition of both escape and avoidance responses in a shuttle-box situation. The present experiment was conducted in order to determine whether the same relationship between learning and UCS intensity would hold in the considerably simpler one-way avoidance task.

Method

The Ss were 41 naive female albino rats from the Carnegie Tech colony which were 60-80 days of age at the start of the experiment.

The apparatus was the same as the one used in the previous study with the following modifications. End partitions were removed which increased the box length to 34-1/2 in. and a 6 x 5 x 8 in. goal box was added to one end with a goal box opening of 2-3/4 x 4-3/4 in. The lights over the box were increased to 25 watts and both lights were on at all times. No tone was used. The shock device was the same one used in the previous study. The shock intensities used for the four groups in this experiment were: Group I (N=9), 0.5 ma; Group II (N=11), 1.5 ma; Group III (N=11), 2.5 ma; Group IV (N=10), 3.5 ma.

At the beginning of a trial the S was placed in the end of the box away from the goal and facing away from the goal. After 5 sec. the appropriate shock level was automatically applied to the grid floor. After the S escaped into the goal box the latency was recorded, the S was removed from the goal box and placed again in the avoidance box for the next trial. The intertrial interval was 25 sec. Fifty trials were given on Day 1 and extinction trials were given on Day 2. The extinction procedure was the same as the learning procedure except that no shock was used. An animal was considered extinguished when it gave a latency of 20 sec.

If, during learning, an S gave 5 latencies of 300 sec. it was considered to be a non-learner and the data was not used in the computation of results. Two Ss

in the 0.5 group and one S in the 2.5 group met the non-learning criterion.

The mean percentage of avoidance responses over all 50 acquisition trials for each of the groups was: 0.5-38.4; 1.5-66.2; 2.5-70.5; 3.5-71.6. Analysis of variance showed that the group means differed significantly ($F=6.62$, $df=3/37$, $p<.01$).

The mean response latencies in blocks of five trials are plotted in Fig. 1. Again the effect of US intensity was significant ($F=3.30$, $df=3/37$, $p<.05$), as was the Trial Blocks effect ($F=8.18$, $df=9/333$, $p<.001$), and the Intensity by Trial Blocks interaction ($F=2.03$, $df=27/333$, $p<.05$). The interaction effect was due primarily to the larger means for the 0.5 and 3.5 ma groups on the first block of trials. Individual comparisons using *t*-tests were made between the group means on Trial Block 1: 0.5 vs. 1.5, $t=17.09$; 0.5 vs. 2.5, $t=17.33$; 0.5 vs. 3.5, $t=12.94$; 1.5 vs. 3.5, $t=3.95$; 2.5 vs. 3.5, $t=4.20$. In all cases $df=37$, $p<.01$. The difference between the 1.5 and 2.5 groups was not significant ($t<1.00$).

The mean number of trials to the first avoidance response for each of the groups was: 0.5-19.7; 1.5-

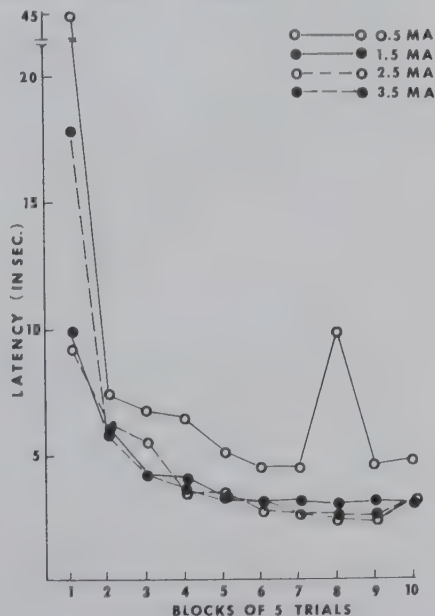


Fig. 1. Escape and avoidance latencies in blocks of five trials.

11.5; 2.5 - 7.2; and 3.5 - 8.2. Analysis of variance showed that the group means differed significantly ($F=3.30$, $df=3/37$, $p<.05$).

The median number of trials to criterion in extinction for the four groups (from 0.5 to 3.5 ma) was 1.2, 2.5, 2.3, and 4.0. The hypothesis of significant group differences was supported by a Kruskal-Wallis test ($H=13.43$, $df=3$, $p<.01$) although Mann-Whitney tests revealed only one significant comparison: 0.5 vs. 3.5 ($Z=2.04$, $p<.05$).

The median latency on the first extinction trial for the 4 groups (from 0.5 to 3.5 ma) was 19.5, 7.4, 13.1, 4.9 sec. Again, the Kruskal-Wallis test was significant ($H=9.47$, $df=3$, $p<.05$). Individual comparisons showed the 0.5 group to differ significantly from the other three groups: 1.5 ($U=24$, $p<.10$), 2.5 ($U=18$, $p<.02$), 3.5 ($U=18$, $p<.05$). None of the other comparisons was significant.

These results indicate that the Ss in the lowest shock group did learn the avoidance response, although that shock level clearly is not optimal. With per cent avoidance, number of trials to first avoidance during acquisition, or latency of first extinction trial used as a criterion, the 0.5 group is significantly inferior to the other groups. The relatively intense shock levels of 2.5 and 3.5 ma do not interfere with the acquisition of one-way avoidance as they do with the more complex shuttle avoidance. However, as Fig. 1 shows, the 3.5 ma level does interfere with the escape response. The latency for the first five trials is significantly longer for that group than for the 1.5 and 2.5 ma groups.

In spite of the fact that the high shock level interferes with escape, the acquisition of the avoidance response is not retarded as is shown by the number of trials to the first avoidance response. Thus, disruption of the escape response alone is probably not sufficient to account for the fact that higher shock intensities retarded avoidance

acquisition in the shuttle box situation as Moyer & Korn (1964) suggested. Theios & Lynch (1965) who also failed to find that high shock interfered with one-way avoidance, hypothesize that the S learns to avoid the location where it has been previously shocked and this learning is a function of shock intensity. Thus, in the shuttle box, the Ss tendency to stay where it is constitutes a competing response which interferes with the acquisition of shuttle avoidance. They further indicate that in situations such as one-way avoidance and instrumental avoidance, where such a competing response is not learned, the higher shock intensities will not interfere with learning. This position is also probably not the whole answer since D'Amato (1965) has shown that high shock intensities do interfere with discriminated bar-press avoidance learning.

The ultimate explanation for the fact that an intense UCS interferes with complex avoidance learning may well involve a number of factors including the "staying response" suggested by Theios & Lynch (1965), the "conditioned response suppression" suggested by D'Amato (1965) and the escape disruption suggested by Moyer & Korn (1964).

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Note

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Relation of cue to consequence in avoidance learning¹

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An audiovisual stimulus was made contingent upon the rat's licking at the water spout, thus making it analogous with a gustatory stimulus. When the audiovisual stimulus and the gustatory stimulus were paired with electric shock the avoidance reactions transferred to the audiovisual stimulus, but not the gustatory stimulus. Conversely, when both stimuli were paired with toxin or x-ray the avoidance reactions transferred to the gustatory stimulus, but not the audiovisual stimulus. Apparently stimuli are selected as cues dependent upon the nature of the subsequent reinforcer.

A great deal of evidence stemming from diverse sources suggests an inadequacy in the usual formulations concerning reinforcement. Barnett (1963) has described the "bait-shy" behavior of wild rats which have survived a poisoning attempt. These animals utilizing olfactory and gustatory cues, avoid the poison bait which previously made them ill. However, there is no evidence that they avoid the "place" of the poisoning.

In a recent volume (Haley & Snyder, 1964) several authors have discussed studies in which ionizing radiations were employed as a noxious stimulus to produce avoidance reactions in animals. Ionizing radiation like many poisons produces gastrointestinal disturbances and nausea. Strong aversions are readily established in animals when distinctively flavored fluids are conditionally paired with x-rays. Subsequently, the gustatory stimulus will depress fluid intake without radiation. In contrast, a distinctive environmental complex of auditory, visual, and tactual stimuli does not inhibit drinking even when the compound stimulus is associated with the identical radiation schedule. This differential effect has also been observed following ingestion of a toxin and the injection of a drug (Garcia & Koelling, 1965).

Apparently this differential effectiveness of cues is due either to the nature of the reinforcer, i.e., radiation or toxic effects, or to the peculiar relation which a gustatory stimulus has to the drinking response, i.e., gustatory stimulation occurs if and only if the animal licks the fluid. The environmental cues associated with a distinctive place are not as dependent upon a single response of the organism. Therefore, we made an auditory and visual stimulus dependent upon the animal's licking the water spout. Thus, in four experiments reported here "bright-noisy" water, as well as "tasty" water was conditionally paired with radiation, a toxin, immediate shock, and delayed shock, respectively, as reinforcers. Later the capacity of these response-controlled stimuli to inhibit drinking in the absence of reinforcement was tested.

Method

The apparatus was a light and sound shielded box (7 in. x 7 in. x 7 in.) with a drinking spout connected to an electronic drinkometer which counted each touch of the rat's tongue to the spout. "Bright-noisy" water was provided by connecting an incandescent lamp (5 watts) and a clicking relay into this circuit. "Tasty" water was provided by adding flavors to the drinking supply.

Each experimental group consisted of 10 rats (90 day old Sprague-Dawley males) maintained in individual cages without water, but with Purina Laboratory chow *ad libidum*.

The procedure was: A. One week of habituation to drinking in the apparatus without stimulation. B. Pretests to measure intake of bright-noisy water and tasty water prior to training. C. Acquisition training with: (1) reinforced trials where these stimuli were paired with reinforcement during drinking, (2) nonreinforced trials where rats drank water without stimuli or reinforcement. Training terminated when there was a reliable difference between water intake scores on reinforced and nonreinforced trials. D. Post-tests to measure intake of bright-noisy water and tasty water after training.

In the x-ray study an audiovisual group and a gustatory group were exposed to an identical radiation schedule. In the other studies reinforcement was contingent upon the rat's response. To insure that both the audiovisual and the gustatory stimuli received equivalent reinforcement, they were combined and simultaneously paired with the reinforcer during acquisition training. Therefore, one group serving as its own control and divided into equal subgroups, was tested in balanced order with an audiovisual and a gustatory test before and after training with these stimuli combined.

One 20-min. reinforced trial was administered every three days in the x-ray and lithium chloride studies. This prolonged intertrial interval was designed to allow sufficient time for the rats to recover from acute effects of treatment. On each interpolated day the animals received a 20-min. nonreinforced trial. They were post-tested two days after their last reinforced trial. The x-ray groups received a total of three reinforced trials, each with 54 r of filtered 250 kv x-rays delivered in 20 min. Sweet water (1 gm saccharin per liter) was the gustatory stimulus. The lithium chloride group had a total of five reinforced trials with toxic salty water (.12 M lithium chloride). Non-toxic salty water (.12 M sodium chloride) which rats cannot readily distinguish from the toxic solution was used in the gustatory tests (Nachman, 1963).

The immediate shock study was conducted on a more orthodox avoidance schedule. Tests and trials were 2 min. long. Each day for four consecutive acquisition days, animals were given two nonreinforced and two reinforced trials in an NRRN, RNNR pattern. A shock, the minimal current required to interrupt drinking (0.5 sec. at 0.08-0.20 ma), was delivered through a floor grid 2 sec. after the first lick at the spout.

The delayed shock study was conducted simultaneously with the lithium chloride on the same schedule. Non-toxic salty water was the gustatory stimulus. Shock reinforcement was delayed during first trials and gradually increased in intensity (.05 to .30 ma) in a schedule designed to produce a drinking pattern during the 20-min. period which resembled that of the corresponding animal drinking toxic salty water.

Results and Discussion

The results indicate that all reinforcers were effective in producing discrimination learning during the acquisition phase (see Fig. 1), but obvious differences occurred in the post-tests. The avoidance reactions produced by

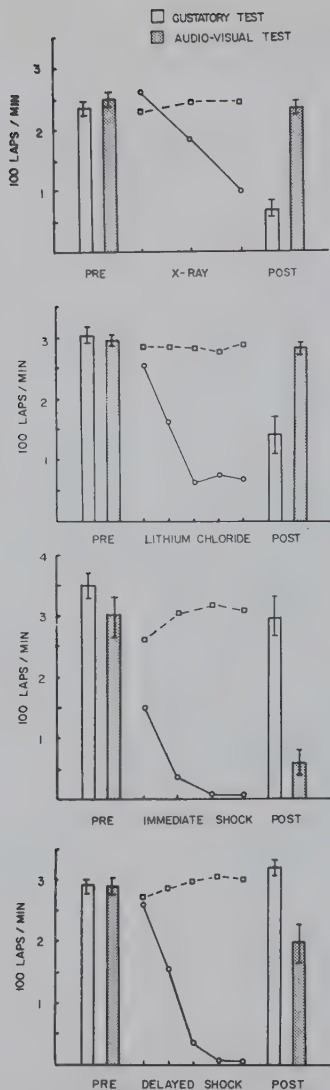


Fig. 1. The bars indicate water intake ($\pm$ St. Error) during a gustatory test (a distinctive taste) and an audiovisual test (light and sound contingent upon licking) before and after conditional pairing with the reinforcers indicated. The curves illustrate mean intake during acquisition.

x-rays and lithium chloride are readily transferred to the gustatory stimulus but not to the audiovisual stimulus. The effect is more pronounced in the x-ray study, perhaps due to differences in dose. The x-ray animals received a constant dose while the lithium chloride rats drank a decreasing amount of the toxic solution during training. Nevertheless, the difference

between post-test scores is statistically significant in both experiments ($p < 0.01$ by ranks test).

Apparently when gustatory stimuli are paired with agents which produce nausea and gastric upset, they acquire secondary reinforcing properties which might be described as "conditioned nausea." Auditory and visual stimulation do not readily acquire similar properties even when they are contingent upon the licking response.

In contrast, the effect of both immediate and delayed shock to the paws is in the opposite direction. The avoidance reactions produced by electric shock to the paws transferred to the audiovisual stimulus but not to the gustatory stimulus. As one might expect the effect of delayed shocks was not as effective as shocks where the reinforcer immediately and consistently followed licking. Again, the difference between post-test intake scores is statistically significant in both studies ($p < 0.01$ by ranks test). Thus, when shock which produces peripheral pain is the reinforcer, "conditioned fear" properties are more readily acquired by auditory and visual stimuli than by gustatory stimuli.

It seems that given reinforcers are not equally effective for all classes of discriminable stimuli. The cues, which the animal selects from the welter of stimuli in the learning situation, appear to be related to the consequences of the subsequent reinforcer. Two speculations are offered: (1) Common elements in the time-intensity patterns of stimulation may facilitate a cross modal generalization from reinforcer to cue in one case and not in another. (2) More likely, natural selection may have favored mechanisms which associate gustatory and olfactory cues with internal discomfort since the chemical receptors sample the materials soon to be incorporated into the internal environment. Krechevsky (1933) postulated such a genetically coded hypothesis to account for the predispositions of rats to respond systematically to specific cues in an insoluble maze. The hypothesis of the sick rat, as for many of us under similar circumstances, would be, "It must have been something I ate."

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Note

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Escape conditioning in snakes employing vibratory stimulation¹

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Eight rat snakes were given 50 paired presentations of light and vibratory stimulation. Ss were tested in a two compartment chamber with a 12 hr. interval between each trial. Moving from one compartment to the other terminated and permitted escape from the vibratory stimulus. Data from two Ss was discarded because of inadequate responsiveness. Except for the terminal block of trials Ss demonstrated a progressive decline in escape time. Individual Ss, however, were highly variable in their performance.

Previous investigations of escape conditioning in snakes have used temperature as the aversive stimulus. Kellogg & Pomeroy (1936) placed water snakes in a water maze containing cold water. A correct response permitted escape into a warm goal compartment. The resultant learning curves showed a high degree of intra- and inter-S variability but did demonstrate a gradual drop in overall response time.

Instead of using heat as a reinforcing condition, Wolfle & Brown (1940) attempted to use it as an aversive stimulus. Essentially no learning was demonstrated when snakes were run, in a multiple T-maze having a dry surface with a high temperature, to a shaded pan of cool water. Wolfle and Brown also attempted using shock as an aversive stimulus. They found it unsatisfactory in that the snakes either did not respond or else responded so strongly as to make learning impossible. Preliminary attempts from this laboratory using varying current and voltage ratings provided by constant current and constant voltage AC and DC sources confirmed this finding. An alternative possibility for an aversive stimulus is vibration. The present report describes an attempt to obtain escape conditioning in snakes using vibration as an aversive stimulus.

Method

Ss were eight rat snakes, six of which were yellow rat snakes, *Elaphe obsoleta quadrivittata*, and two were the similar Everglades or "orange" rat snake, *Elaphe obsoleta rossalleni*. The length of the snakes varied from 88.9 to 132.1 cm at the beginning of the experiment. They were housed in individual aquariums located in a room maintained at an approximate temperature of 25.5° C. Ss had ad lib access to water. All Ss but one were fed young rats once weekly. The largest S, a yellow rat snake, refused to eat and was force fed two eggs weekly.

The apparatus was a rectangular chamber 61.0 x 30.5 x 40.6 cm in length, width and height, respectively. The chamber was divided into two compartments of equal size by a partition which had a 5 cm gap across the floor. The gap permitted passage of a snake from one com-

partment to the other. The floors of both compartments were separate and isolated, being independently suspended from the entire apparatus by foam rubber pads. Except for the floors and the side facing the experimenter, which was a sheet of clear plastic, the entire apparatus was made of plywood sections fitted to an aluminum frame. The start compartment, located on the experimenter's right, was unpainted on the interior. The remainder of the apparatus was painted flat black. The tops of the start and escape compartments were separately hinged, and the top of the start compartment had a light fixture containing a 15-w 120 VAC lamp located in the center. A 6 VAC buzzer was mounted on the underside, and in the center of the floor of the start compartment. The entire apparatus was placed upon blocks of acoustical insulation to further control extraneous vibration. A control box containing switches, a transformer, relays, etc., was used to present the vibratory and visual stimuli, and to operate a chronometer.

Two trials a day were given to each S with a 12-hr. interval between trials. Ss were not run during ecdysis so that there was on occasion more than a 12-hr. lapse between two trials for a particular S. On each trial the experimenter released the head and body of S within the start compartment in as much the same manner on each trial as possible. The lid of the start compartment was then closed and the control apparatus was operated within approximately 5 sec. Closing a switch turned on the overhead light and started the chronometer. After 5-sec. light duration a time delay relay turned on the buzzer until an escape response was made. An escape response was defined as one in which the head and body, i.e., all of the snake except from the vent caudally, were in the escape compartment. If S had not escaped within 25 sec. from onset of the buzzer the trial was considered terminated and S was removed from the apparatus. The weekly feeding was always given immediately after an evening trial so as to produce minimum interference with performance.

Results and Discussion

The performance of one yellow rat snake, no. 5, was irregular and inadequate. Another yellow rat snake, no. 6, responded to the vibratory stimulus as though it were positively reinforcing. On all trials but two this S coiled herself in the center of the start compartment directly over the buzzer. The data for the remainder of Ss are presented in Fig. 1. It can be seen that there is a progressive decline in escape time except for the last block of trials. The increase in the last block of trials was produced by what appeared to

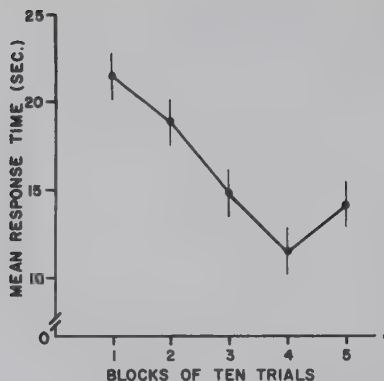


Fig. 1. Mean escape time (sec.) for six snakes.

be adaptation to the vibratory stimulus. Individual behavior of Ss was highly variable from trial to trial although the standard error of the mean for the blocks of trials, shown in Fig. 1 by the vertical bars through each point, in every case was 1.2 sec. when rounded

to the nearest 1/10 sec. It should be pointed out that the curve for eight Ss is almost identical to that for six Ss except for greater variability measures for the larger number of Ss.

Although it must be concluded that the Ss demonstrated a meaningful drop in response time the intensity of vibratory stimulation was not optimal. The failure to observe any avoidance responses and the terminal adaptation to the vibration would seem to confirm this opinion. The present study would probably have been improved by using smaller compartments in the test apparatus and by using a one-way screen instead of a transparent front.

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Note

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The development of rapid running in T-mazes in the absence of obvious rewards¹

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Rats run in T-mazes with arms inclined or horizontal greatly increased their speed of running during large numbers of unrewarded trials given both prior to and after the introduction of food rewards to the goal boxes. After developing fast speeds on unrewarded trials, the presence of food rewards in the goal boxes caused Ss to decrease their speed of running from the start box to the door of the goal box, although it increased their speed of entering the goal box.

In a series of experiments not yet published, we observed a marked increase in the running speed of rats during prolonged extinction trials in a T-maze with arms inclined at 50° . An initial decrement in running speed and a return of arm preference to chance over the first 40 to 80 extinction trials were followed by a steady increase in speed until, at the end of 300 extinction trials, Ss were running at twice their asymptotic speed of running to food.

The purposes of this experiment were to determine (1) if an increase in running speed over a large number of unrewarded trials is peculiar to a maze with inclined arms; (2) if the phenomenon can be obtained with unrewarded trials before as well as after food-rewarded trials; (3) if Ss run in a T-maze with one arm horizontal and the other inclined at 50° will develop a preference for the 50° arm along with increased speeds on unrewarded trials.

Method

The Ss were nine experimentally naive male hooded rats obtained from the Quebec Breeding Farms of St. Eustache, Quebec. They were 100 days old. Prior to the experiment and between sessions Ss were individually caged in 7 in. x 10 in. x 7 in. Wahmann cages.

The T-maze was 4 in. wide and 12 in. high. The lengths were: start box—12 in., stem—24 in., arms—52 in. The goal boxes were 12 in. x 12 in. x 12 in. The arms, from 12 in. from the stem to 3 in. from the goal box, could be inclined at 50° from the horizontal. The maze, painted flat black, had a Plexiglas top and fine wire mesh on the floors. A guillotine door separated start box from stem. At the entrances to the arms and goal boxes were one-way push-through doors.

Taming and food-deprivation lasted for 14 days during which S was reduced to 75% ad lib weight with a 22-23 hr. food-deprivation schedule and handled for 5 min. each day. Preacquisition consisted of 300 unrewarded trials grouped in 20 daily sessions, acquisition of 105 trials in 7 daily sessions, and extinction of 150 unrewarded trials in 10 daily sessions. During acquisition

there was a 45 mg food pellet in both goal boxes on every trial. The daily food ration was given 1 hr. after the completion of an experimental or handling session.

The running procedure in all phases was as follows. The S was placed in the start box facing away from the guillotine door. When S turned to face the door, the door was raised. The S was timed in .01 min. from start-box departure to arrival at goal-box door and to entry into goal box. After 10 sec. in a goal box S was placed in a holding cage for 15 sec. prior to the start of the next trial. The first 10 preacquisition trials had a maximum limit of 5 min.; thereafter the limit was 2 min. If S had not reached a goal box within the time limit, it was removed directly to the holding cage to await the start of the next trial.

There were three maze conditions: $0^\circ-0^\circ$ (both arms horizontal), $50^\circ-50^\circ$ (both arms inclined), and $0^\circ-50^\circ$ (one arm inclined). Three Ss were run under each condition. No Ss were discarded because of failure to run.

Results

Two running speed measures are reported: runway speed (reciprocal of time from start box departure to arrival at the goal-box door) and goal speed (reciprocal of time from arrival at the goal-box door to goal-box entry). For each of the three groups mean runway speeds and goal speeds over the 37 sessions of 15 trials are shown in Figs. 1 and 2.

Within both preacquisition and extinction runway speed and goal speed increased significantly. The introduction of food into the goal boxes (i.e., acquisition) had opposite effects on the two speed measures, decreasing runway speed and increasing goal speed.

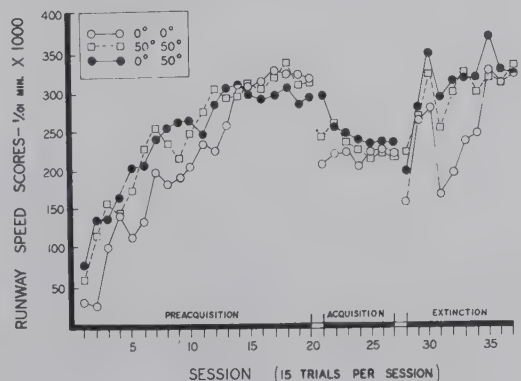


Fig. 1. Runway speed scores during preacquisition, acquisition, and extinction in the $0^\circ-0^\circ$, $50^\circ-50^\circ$, and $0^\circ-50^\circ$ T-mazes.

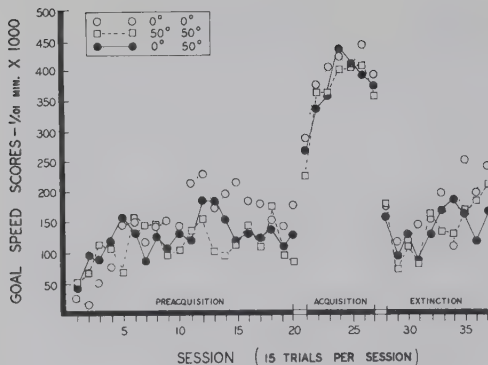


Fig. 2. Goal speed scores during preacquisition, acquisition, and extinction in the 0°-0°, 50°-50°, and 0°-50° T-mazes.

The only effect of maze inclination was a session by inclination interaction in runway speed during preacquisition. This reflected the somewhat delayed development of fast running the 0°-0° maze.

With food in the goal boxes, two of the three Ss run in the 0°-50° maze developed a preference for the 0° arm. During preacquisition and extinction, preference for the 0° and 50° arms varied around chance for all three Ss. An analysis of runway speeds for trials on which the 0° and 50° arms were chosen indicated that speeds were faster with a 50° arm choice during preacquisition, faster with a 0° arm choice during acquisition, and not different with 0° and 50° choices during extinction.

Discussion

The presence of obvious rewards (food) in the goal boxes decreased the speed of running through the major portion of the maze but increased the speed of entering the goal boxes; it also produced a tendency to reach the goal box by the less effortful arm in the 0°-50° T-maze—a tendency which was not present on unrewarded trials. These observations (both of which have been confirmed in other experiments in the series) make it awkward to account for increased

speeds over "unrewarded" trials in terms of a hypothetical reward which acts subsequent to S's arrival in a goal box.

The gradual development of fast speeds over a large number of preacquisition trials bears some resemblance to the gradual development of fast wheel running without extrinsic reward (e.g., Finger, Reid & Weasner, 1957). Demonstrations of the reinforcing value of wheel running (e.g., Premack, Schaeffer, & Hundt, 1964) suggest that running may be an intrinsically appealing or self-reinforcing act for the activity-deprived rat. An experiment is in progress to see if the opportunity to run in a maze will reinforce bar pressing in the start box.

Experiments not yet published suggest that massed trials and brief goal-box confinement times are critical conditions for the development of fast running speeds over unrewarded trials. We are not aware of any experiment with a large number of preacquisition trials which has met these conditions. There are, however, many experiments with brief confinement and massed trials during extinction. Although there probably are other conditions that are critical, the failure of these experiments to obtain increasing speeds during extinction is most easily explained by the early termination of extinction trials. While runway speeds in the present experiment had increased noticeably by the 30th extinction trial, in our previous experiments with no preacquisition trials, speeds during extinction declined in an expected fashion for 40 to 80 trials and reached conventional extinction criteria before beginning to increase.

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Note

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Passive avoidance response learning as a function of prior tumbling-trauma¹

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THE MENNINGER FOUNDATION

The effect of extensive prior tumbling, as a substitute for traumatic pre-shock, was studied in rats using an approach-avoidance conflict test procedure involving successive response to food, punishment (shocks), food, and punishment (air-puffs) again. Tumbled Ss, while performing similarly to controls under the appetitive conditions, reacted more strongly to both punishments by stopping sooner, running slower, and exhibiting lower skin resistance when approaching the ambivalent goal. An apparent contradictory effect of tumbling also was discovered.

Prior aversive stimulation (PAS) or trauma has been shown to facilitate the acquisition of both an active and passive avoidance response (Brookshire, Littman, & Stewart, 1961; Kurtz & Walters, 1962). Typically, investigations of the effects of PAS have employed procedural variations designed to rule out transfer of conditioned fear from the treatment to the test situation as the sole explanation of the data. However, most PAS studies have employed electric shock as both the traumatizing agent and the aversive test stimulus, thus ignoring the possible mediational role of shock cues. The present study was planned, then, to evaluate whether a PAS effect could be demonstrated when the aversive treatment and test stimuli were qualitatively different, and was predicted on evidence that prolonged tumbling might offer a suitable substitute for shock-trauma (Noble, 1953; Noble & Collip, 1942).

Method

The Ss were 24 naive, 90 day old, male albino rats maintained in The Menninger Foundation colony. The treatment apparatus was a circular drum divided into five 10 in. in diameter by 7 in. wide compartments. The floor was covered with polyethylene, and, to facilitate tumbling, two paddles were located on opposite sides of each cage. Rotation speed was 54 rpm. The test apparatus, described in detail elsewhere (Brown & Hoopes, 1965), was a straight alley. The gridded floor was supported at its midpoint by a knife-edge fulcrum, being free to pivot relative to the walls of the alley. Displacements of the floor were transmitted and recorded by an appropriate transduction and ink-writing system. From the graphic records determinations could be made of the point at which S first stopped approaching, etc. Running times were obtained by a system of photo-relays and clocks. Basal skin resistance (BRL) was recorded according to a technique described elsewhere (Kaplan & Hobart, 1964).

The test shock was the 60 cycle output of a variable autotransformer through a 20K resistor. Air-puff was

administered through 1/4 in. copper tubes mounted around the alley food cup.

All Ss were placed on a 23.5 hr. food Td schedule to reduce them to an 80% body weight which was maintained throughout the remainder of the investigation. The Ss were then administered 51 alley food "shaping" and training trials spaced over 6 days, and then, on the basis of their asymptotic running speeds, were matched and randomly assigned to one of two groups of 12 Ss each ($F < 1$).

Tumbling treatment then was initiated for one group (T), while the other group served as controls (C). The tumbling schedule was 500 continuous rotations (r) on days 1 and 2, 750 r on days 3 to 5, 1000 r on days 6 and 7, 1250 r on days 8 and 9, 1500 r on days 10 and 11, and 2000 r on days 12 and 13. Tumbling was accomplished by carefully taping the front paws and hind paws to each other. The Ss of the C group were treated identically except that they were not rotated.

Two days later all Ss were returned to the alley and administered three reacquisition trials. Two reacquisition, four test shock, and one shock recovery trials were given on the following day. Test shock (0.3 sec., 30 v) was administered to all Ss as they contacted the food cup.

Because the T group might have developed sore paws from the tumbling treatment (even though feet were completely taped), both groups were again food-trained to bring them back to near-asymptotic running speeds. Two trials involving presentation of a 0.2 sec. 50 lb psi air puff were then administered to all Ss as they contacted the foodcup. Three puff recovery trials followed. If Ss did not run in 60 sec. on either shock or air test trials, it was placed in the food area and appropriately shocked or "puffed." Food was available on all trials.

The next day control Ss were individually administered 2000 consecutive r (paws taped), and number of deaths were recorded.

Results

The graphic records of the S's behavior in the alley were read to determine, among other things, the distance from the goal at which each S first stopped. Initial stopping point has been defined elsewhere (Brown, Anderson, & Brown, 1965). If S did not stop, it was arbitrarily assigned a value of 8 in. BRL data were the lowest resistance recorded on a given trial. Running times were converted to speed measures.

While group performances were significantly different on the last reacquisition trial prior to test shock, the difference between running times was only 0.3 sec.

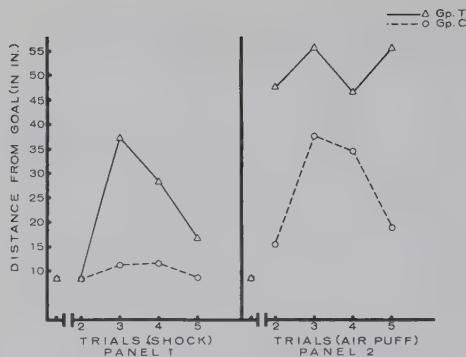


Fig. 1. Stopping points, averaged and analyzed for groups. Panel 1 represents performances of the T and C groups for the last three shock and first shock recovery trials. Panel 2 represents performances of the same groups on the second air-puff and next three puff recovery trials. Points in the extreme left column of each panel represent group performances on the first shock and first puff trial respectively.

($\bar{X}_T=1.49$; $\bar{X}_C=1.20$), and performance of the T group was not different from their pretumbling running times ($F=1.29$, $df=1/11$, $p<.05$). Stopping points, averaged and analyzed for groups, for the second, third, and fourth shock and first shock recovery trials are shown in panel 1 of Fig. 1. The F s for groups, trials, and groups by trials interaction were highly significant ($F_g=10.35$, $df=1/22$, $p<.005$; $F_t=14.06$, $df=1/11$, $p<.005$; $F_{gt}=30.19$, $df=1/11$, $p<.001$). A covariance analysis of the speed data provided essentially similar results.

BRL was significantly lower for the T group on all reacquisition and test shock trials, and an analysis of covariance indicated that test shock did not produce a differential lowering effect ($F<1$).

Again, while mean running speeds were significantly different for the two groups on the last reacquisition trial prior to air-puff, both groups averaged less than 2.0 sec. ($\bar{X}_T-\bar{X}_C=0.7$ sec.). Panel 2 of Fig. 1 shows stopping points, averaged and analyzed for groups, for the second air-puff and subsequent three puff recovery trials. Group performances were significantly and substantially different ($F=13.33$, $df=1/22$, $p<.01$). The F for trials barely reached significance, and the interaction did not. Again, a covariance analysis of running speed data provided similar results.

By the last two shock recovery and first puff trials baseline BRL was identical for both groups ($F=1.89$, $df=1/22$, $p>.05$), hence, a covariance analysis was not necessary. A groups by trials analysis of variance was performed on the data, expressed in K ohms, for the first and second air-puff and three puff recovery trials. The F s for groups and trials were significant ($F_g=4.42$, $df=1/22$, $p<.05$; $F_t=10.49$, $df=1/11$, $p<.005$) while the interaction was not.

Five of the 12 C Ss died from the tumbling given

following testing, although the identical dose on the last treatment day had not produced a single fatality in the T group. A χ^2 comparing the frequency of deaths for both groups was highly significant ($\chi^2=6.32$, $df=1$, $p<.02$).

Discussion

These results indicate that a qualitatively different PAS treatment from electric shock can produce similar effects, and provide important support for the construct of "trauma-residua" as a descriptive term. Indeed, since there were also substantial dissimilarities between the treatment and test situations, a stimulus generalization and/or transfer of conditioned emotionality explanation does not appear to adequately handle the findings of this report. Gross bodily impairment also does not appear a likely explanation since the findings of Noble & Collip (1942) indicate that tumbling-trauma produces little or not hemorrhage, or macroscopic damage to internal organs or the CNS. Also, by the last reacquisition trial prior to test shock Ss of the T group showed no perceptible difference from their pretumbling performance, further arguing against a bodily damage hypothesis. Perhaps a more generalized mediational mechanism is involved which utilizes cues common to all aversive stimuli irrespective of their origin.

Of further interest is the finding that the same PAS event, when viewed in one test situation, can be said to have a "sensitizing" effect (facilitated acquisition of a PAR), and, when viewed from yet another, to have a "toughening up" effect (resistance to normally lethal doses of tumbling). Further investigation is underway in our lab regarding this finding.

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Notes

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Acquisition of a passive avoidance response as determined by variations in prior aversive stimulation¹

D. CHRIS ANDERSON², H. W. TYSON AND F. WILLIAMS³

THE MENNINGER FOUNDATION

The effects of various forms of prior enforced sleep Td (SD) and of pre-shock (PS), as presumed traumatizing agents, were studied in rats 15 days following treatment using an approach-avoidance test procedure involving successive response to food, mild punishment, food, and weak punishment. PS Ss and Ss whose SD treatment involved prolonged walking on an abrasive surface exhibited greater avoidance of the food area to mild punishment than controls, while Ss whose SD treatment consisted of prolonged walking on a smooth surface or prolonged standing in deep water exhibited significantly less conflict. With one exception, similar results were obtained under the weak test punishment.

Pearl, Walter, & Anderson (1964) found that rats who were subjected to prior enforced sleep deprivation (SD) more rapidly acquired a passive avoidance response (PAR) relative to non-SD controls in an approach-avoidance conflict test situation. To analyze this result the present study was designed to evaluate the following possible explanations: (1) Sore feet, resulting from enforced prolonged walking on abrasive hardware cloth, may have provided cues which became conditioned to the rolling semi-tumbling response observed near the end of the SD treatment. Subsequent shock to the feet in the test situation may have been enough like the painful SD condition to elicit similar behavior incompatible with the approach response; (2) Prolonged enforced exercise may have had a traumatizing effect similar to that of pre-shock (PS) as also reported by Pearl et al (1964); (3) SD per se conceivably may have been traumatizing; (4) All of the above three variables may have worked in concert to produce a prolonged state of overarousal, which, in turn, served as a severe trauma (cf. Malmö, 1957). A PS group was included in order to directly compare the effects of two qualitatively different forms of aversive stimulation on subsequent responses to punishment.

Method

The Ss were 50 naive, 90 days old, male albino rats maintained in The Menninger Foundation colony. The PS chamber was similar to that described elsewhere (Kurtz & Pearl, 1960). The SD apparatus was a circular drum divided into five 10 in. in diameter by 7 in. wide compartments. The test apparatus, described in detail elsewhere (Brown & Hoopes, 1965), was a straight alley, and provided graphic determinations of the point at which S first stopped approaching, etc. Running times were recorded by a system of photo-relays and clocks. The

test shock was the 60 cycle output of a variable auto-transformer through a 20K resistor. The treatment shock source was a 7500 v neon transformer through a 6M resistor.

The study was run in 2 replications of 25 Ss each. Three groups of 10 Ss were SD. One SD treatment duplicated that of Pearl et al (1964), and involved 30 hr. of SD in the drum on hardware cloth (SD_A) at 5.7 rpm over a 31 hr. period (1 hr. of non-rotation was inserted for eating and drinking at the end of the first 24 hr.). The drum floor was covered with polyethylene to minimize sore feet while administering an otherwise equivalent SD treatment to another group (SD_S). The Ss of Group SD_S did not develop foot blisters as did Ss of Group SD_A. By the 8th day following treatment, the paws of the SD_A Ss had healed. To control both for sore paws and prolonged walking, a third group (SD_W) was forced to remain awake by standing on small 1-1/2 sq. in. pedestals located 1 in. below the surface of 9 in. deep water. A preliminary study indicated that the SD_W Ss would remain awake for the 30 hr. period.

The PS Ss each received nine 5 sec. free shocks randomly spaced over a 30 min. period. The C Ss were handled and confined in the SD or PS apparatus for durations comparable to experimental Ss, but were neither rotated nor shocked.

Nine days after treatment, Ss were placed on food Td, reduced to 80% body weight (maintained during the rest of the study), and then administered 61 alley food training trials spaced over 7 days. On the following day all Ss were given 2 or 3 mild shocks (0.5 sec. at 50 v) in the goal area of the alley (equated for groups). Three recovery trials per day were given thereafter until all groups were again equal in running times. A second test session was marked by again subjecting all Ss to weak shock (0.3 sec. at 40 v) as they entered the goal area on each of the next 5 consecutive trials. Food was available on all test shock and shock-recovery trials.

Results

Mean group running times were identical for the last 10 acquisition trials ($F < 1$). To reduce heterogeneity and skewness running times for all test trials were converted to logarithms. Figure 1 portrays group log running times, averaged and analyzed for each trial, on each of the three days following the initial mild test shock. Several major conclusions are represented in this figure and were supported by a 5 by 3 by 3 factorial

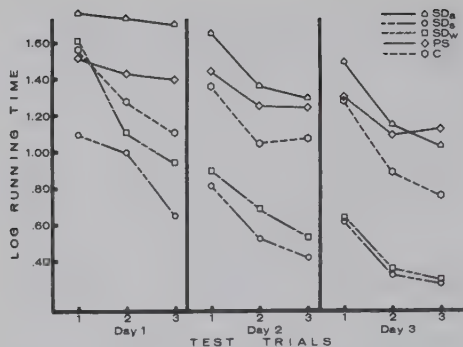


Fig. 1. Group log running times, averaged and analyzed for each trial, on each of the three days following initial test shock. SD_a , SD_s , SD_w , PS, and C represent prior treatment conditions consisting of sleep deprivations (SD) entailing enforced locomotion on an abrasive surface, SD involving locomotion on a smooth surface, SD induced by forced standing in deep water, preshock, and control respectively.

analysis of variance (cf. Winer, pp. 319f, 1962). The Fs for all main effects were significant, while none for the four interaction effects were (for groups, $F=4.42$, $df=4/45$, $p<.005$; for days, $F=54.76$, $df=1/45$, $p<.001$, and for trials, $F=50.01$, $df=1/45$, $p<.001$).

A comparison between the weighted performance totals of the PS and SD_a groups vs. the weighted totals of the remaining three was highly significant ($F=12.06$, $df=1/45$, $p<.005$). The only other significant F resulting from grand mean comparisons was between the C group vs. the weighted average of the SD_w and SD_s groups ($F=4.71$, $df=1/45$, $p<.05$).

A non-significant F of 2.45 ($df=4/45$, $p<.05$) for trial one of the second test session confirmed the success of the retraining procedure for equating group performances. A 5 by 5 factorial analysis of variance was employed to evaluate the data of this second set of punishment trials. The F for groups ($F=6.69$, $df=4/45$, $p<.001$), and the F for trials ($F=10.38$, $df=1/45$, $p<.005$) were highly significant, while the interaction was not.

The conclusions based on grand mean comparisons were, with one exception, identical to those revealed by the grand mean analyses for the first test session. The one exception was that, under weak punishment, performance of Group SD_a was indistinguishable from controls.

Discussion

Of the three SD conditions, the initial test punishment facilitated acquisition of the PAR only for Ss who had

received the SD_a treatment, clearly replicating the findings of Pearl et al (1964). In accord with the first of the four hypotheses put forth in the introduction, these results convincingly implicate the mediational significance of the cues resulting from the insult to foot tissues sustained both in the prior treatment and subsequent test situations by Ss of the SD_a group.

Those treatments which involved only prolonged exercise and/or SD while minimizing macroscopic foot injury (the SD_s and SD_w groups, respectively) produced, if anything, an attenuation rather than facilitation of the acquisition of a PAR. That this latter finding is not solely attributable to the development of calloused or toughened paws by Ss of the SD_s group (due to prolonged walking) is supported by the fact that Ss of the SD_w group (who did not engage in walking) also exhibited an attenuated response to test punishment.

The results indicated that both PS and SD_a treatments worked to produce similar, albeit non-identical, effects. In general, both treatments rendered S more vulnerable than controls to the disruptive effects of punishment. Conversely, the SD_w and SD_s treatments worked similarly to render S less responsive to later punishment. Indeed, these relationships were generally stable over two consecutive test sessions suggesting a certain permanency in the respective treatment effects. If correctly inferred from the data, there may exist a continuum of effect along a dimension of intensity or prior aversive stimulation (PAS). A certain amount of such treatment may work to "toughen" S to subsequent normally stressful encounters, while excessive amounts of PAS may have an opposite and debilitating effect.

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Notes

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2. Now at Brigham Young University.
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Inferences about visual mechanisms from monocular depth effects¹

FRED ATTNEAVE AND RICHARD K. OLSON

UNIVERSITY OF OREGON

Two depth "cues," radial patterning and relative length, were presented in sufficiently pure form to permit inferences about underlying data-processing operations. Over 18 O's, the former property yielded a strong depth impression, the latter a weaker one. Depth effects from dot patterns were dependent on perceptual grouping of dots into radial lines.

The properties of a monocular field that give rise to depth impressions have not typically been specified with precision. Ideally, the specification of a given "cue" would be formally equivalent to a description of the information-processing required to abstract the relevant property. This level of description is not unattainable, but it demands unusual attention to stimulus-control.

The perception of depth in a figure like 1a (after Gibson, 1950) might be attributed to any or all of a number of properties: (1) The transverse lines vary in slope, as radii of a circle. (2) The distance of each such line from its neighbors increases (linearly) from left to right. (3) The distances between verticals increase from left to right in accordance with a perspective rule. (Either the 1-2 gradient or the 3 gradient can produce a depth impression without the other; see Gibson, 1950.) (4) However, contour-density (average amount of line per unit area) increases concomitantly with both of the preceding gradients from right to left. (5) Likewise, object-density (number of trapezoids or of line segments per unit area) increases from right to left. (6) Object-size (area of trapezoids or length of line segments) varies inversely. The criterion for separating these variables is simply that each corresponds to a different set of possible operations on the proximal stimulus-data.

Stimuli

Displays were designed to test the effects of two potential depth cues—radial arrangement of lines (1) and relative length of linear elements (6)—with other, normally confounded cues controlled as strategically as possible.

Figures 1b and 1c employ the same principle of control; verticals are so spaced that average contour-density remains constant across the figure. Although the verticals do not follow a perspective gradient, their spacing might be expected to oppose the radial effect. Object-size (area of trapezoid) and object density are shallow non-monotonic functions of horizontal locus (inverted-U and U respectively); i.e., trapezoids at either side are a little larger than intermediate ones. If effective in the present displays,

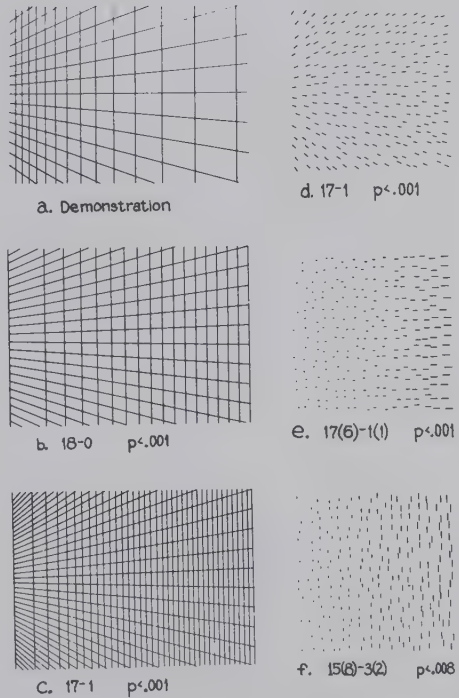


Fig. 1. Linear displays. Under each, number of O's reporting recession to the left and right respectively (in terms of the present orientation) is shown. Parenthetical numbers indicate forced choices.

these variables would create an impression of concavity, which does not in fact occur. Two aspects of radial lines—(1) and (2) above—remain confounded, however.

This defect is remedied in Fig. 1d. Here, an appropriate radial segment of constant length was randomly positioned within each cell of a 16 x 16 construction grid, in such a manner as to break up alignments into precise rows and columns, without allowing elements to touch. It holds constant all the variables mentioned except slope-gradient.

In Figs. 1e and 1f, relative length of line segments is the independent variable. Object-density is held constant by randomly placing one element in each construction cell. Length gradients follow the perspective rules for physically equal elements, of the respective orientations shown, but elements in 1c are made horizontal rather than radial in deliberate violation of

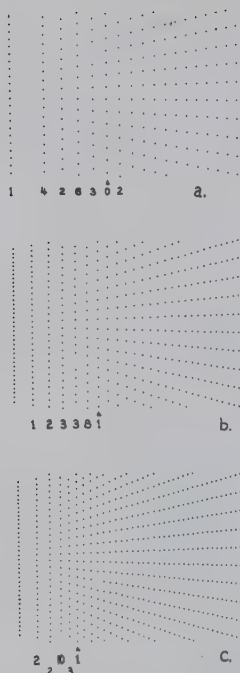


Fig. 2. Dot-patterns. The number under a column indicates the frequency with which the column was chosen as the inflection point of the surface. Pointer shows locus of equal spacing between columns and radii, measured at middle radius.

perspective rules. Two variables—*contour density* and *space between elements*—remain uncontrolled, but if effective, they will oppose the length variable.

Three dot patterns (Fig. 2) were used to study a relationship between perceptual grouping and depth perception. Dots are arranged in radial rows and vertical columns with dots closer in columns on one side and in radii on the other. The pointer indicates the locus of equidistance.

Procedure

Eighteen young adults, 5 men and 13 women, served as O's. The displays, in India ink on 9 in. x 12 in. cards, were presented at a distance of 5 ft. Figure 1a was shown as a demonstration. O was then asked to tell, for each of the line displays (Figs. 1c-f), the direction in which the surface seemed to recede. When necessary, a forced choice was demanded ("If you had to say that one side looks farther away...") Order of presentation and left-right orientation of

figures were randomly permuted for each O, except that each display was presented equally often in each orientation over all O's. The dot patterns were then presented, with order and orientation likewise varied. On the first one, O was asked to report direction of recession and "anything else interesting" that he noticed. All but one O (who had to be told what to look for) reported spontaneously that beyond some point the surface stopped receding, or flattened out. O was then asked to indicate exactly where this discontinuity occurred in each display.

Results and Discussion

Results with 1b and 1c show that a radial arrangement of lines effectively creates a depth-impression. Responses to 1d show that a *radial slope-gradient* alone is effective, i. e., that distance between radial elements need not vary. Effects from 1e and 1f are weaker (possibly because of the opposing variables), but still show unequivocally the operation of a *length-gradient*. (The imperfections of control mentioned earlier would present problems of interpretation only if the opposite result had been obtained.) In terms of information-processing, it seems minimally necessary to postulate (a) a slope-detecting operation, (b) a further mechanism responsive to functional relationships between slope and spatial position; likewise mechanisms for detection of (c) length and (d) length-place relationships.

The impression of a receding surface in the dot patterns (Fig. 2) clearly depends on perceptual grouping of dots into radial lines. The primary variable is relative proximity; however, the depth impression (and presumably the underlying grouping) typically perseverates for about two columns beyond the equidistance point. These results imply that proximity-grouping occurs *prior to* depth perception. A study by Rock & Broscole (1964) seems to show the reverse: they found grouping based on phenomenal rather than retinal proximity where the former was dependent upon (binocular) depth perception. It may be that the mechanisms for grouping and depth perception are not related in a fixed sequence, but that each operates on the output of the other in an iterative manner. Perseveration of perceived depth beyond the equidistance point would follow from this hypothesis.

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Note

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Vibrotactile sensitivity and the frequency response of the Pacinian corpuscle¹

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Threshold responses to vibratory stimuli are compared for psychophysical and electrophysiological experiments. There is a striking similarity between the two sets of data. The hypothesis that a duplex mechanism for taction is supported and there is compelling evidence that the Pacinian corpuscle is the neural transducer of vibratory stimuli.

After a century of investigation and controversy, the question of cutaneous receptor specificity remains open to question. Von Frey (1897) neatly and firmly based cutaneous sensibilities on a foundation of four morphologically distinct types of nerve endings. By 1912 this foundation had been broadened to include as many as 34 separate terminations (Botezat, 1912). In a series of papers the Oxford group (Weddell, Palmer, & Pallie, 1955) brought down this edifice asserting that there was no anatomical evidence that specific end organs exist in mammalian skin.

Using psychophysical methods, Békésy (1940) concluded that vibration and pressure were mediated by separate receptor systems. Geldard (1940) on the other hand, finding a coincidence between pressure and vibration spots, marshalled considerable evidence showing that one set of receptors served both types of stimuli.

In a series of psychophysical experiments on human glabrous skin, the present author demonstrated that when very small contactors are used, the frequency response from 25 to 640 cps is essentially flat (Verrillo, 1963). As the area of the contactor is increased, a family of parallel U-shaped curves is generated with a maximum of sensitivity in the region 250-300 cps. This data has led to the hypothesis that there are two (at least two) functionally distinct types of mechanoreceptors involved in taction: one whose response is dependent upon frequency and one that is frequency independent. A repeat of this experiment on the hairy skin of humans (Verrillo, in press) supports these findings.

The hypothesis of a duplex mechanism for mechanoreception would be strengthened if a receptor responsive to vibration were known. Scott (1951) and others have demonstrated that the Pacinian corpuscle is sensitive to vibratory stimulation. More recently, neural units sensitive to vibration were located in the leg of cat (Hunt & McIntyre, 1960) and identified as Pacinian corpuscles (Hunt, 1961). Those units investigated by Hunt followed the physical stimulus at a 1:1 ratio from about 40 to 90 cps up to the region of 800 cps.

Sato (1961) was able to measure the frequency characteristics of Pacinian corpuscles, *in situ* in the mesentery of cat. His data provide a unique opportunity for comparing the electrophysiological and psychophysical information. Figure 1 compares the frequency response of two Pacinian corpuscles (Sato, 1961) and psychophysical thresholds obtained on the glabrous skin of the human hand (Verrillo, 1963).

Appropriate transformations of Sato's data have been made in order to make them comparable on the same coordinates with the psychophysical data. All of the threshold values are absolute. Threshold for the physiological data was defined as a steady neural firing recorded from the axon in response to direct mechanical stimulation of the intact corpuscle. Psychophysical thresholds were obtained by the method of limits, each data point representing the median of three tests on each of three subjects.

The data show a striking similarity in the general shape of the functions for a large contactor (2.9 cm²) and for the Pacinian corpuscle. Both functions have a slope of about -12 db per doubling of the frequency with a minimum in the region 250-300 cps (solid lines), before rising again in the upper frequencies. The psychophysical curve for a small contactor (.02 cm²) is essentially flat (dashed line) and in the lower frequencies (25-40 cps) the data for the large contactor also follow a flat curve.

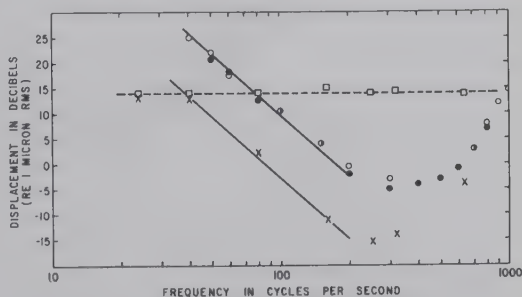


Fig. 1. Absolute thresholds as a function of the frequency of sinusoidal vibration. ●, ○ - Response of two Pacinian corpuscles in cat mesentery, tested electrophysiologically *in situ* (Derived from Sato, 1961). □, X - Responses of three human subjects, tested psychophysically on the glabrous skin of the hand. Contactor areas: X - 2.9 cm²; □ - .02 cm² (Verrillo, 1963). The slope of the solid lines drawn to fit the data points is -12 db per doubling of the frequency. The dashed line is the curve for the very small contactor.

In an earlier paper (Verrillo, 1963) this flat curve was interpreted as the response of frequency independent receptors. These receptors dominate the threshold response until a sufficient number of frequency dependent endings can summate spatially, as the contactor size is increased, producing the downward slope of the curve. Békésy (1939) also has recorded a relatively flat frequency function from 0.3 cps to about 20 cps. Since neither Hunt (1961) nor Sato (1961) were able to elicit response from Pacinian corpuscles below 40 cps, it is reasonable to assume that another type of receptor is responsible for the psychophysical threshold at frequencies below the region of 40 cps.

The evidence reported here support the hypothesis that two functionally distinct systems of nerve terminations mediate tactual sensitivity. Both psychophysical and electrophysiological evidence support this hypothesis. When the two types of data are compared on the same coordinates, it is evident that the Pacinian corpuscle, a morphologically distinct terminal, is the nerve ending that determines the threshold response to vibratory stimuli.

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Note

1. This work was supported by a contract between the National Institutes of Health, U. S. Department of Health, Education, and Welfare and Syracuse University. Reproduction in whole or in part is permitted for any purpose of the U. S. Government.

The perception of experimentally induced failure¹

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A simulated decision making environment was used to examine the relationship between experimentally induced failure and Ss' perceptions of success and failure. The obtained relationship between induced and perceived failure was generally linear, with a significant higher order trend. The implications of these findings for homeostatic and adaptation level theories of perception are considered.

Since level of failure is a rather common experimental manipulation, it would seem profitable to examine the relationship between the experimental manipulation of failure and Ss' perceptions of success and failure more closely. Frequently, Es have assumed a direct correspondence between experimentally induced failure and perceived failure (e.g., Atkinson, 1957; McClelland, Clark, Roby, & Atkinson, 1949). However, available evidence would seem to indicate that the relationship could be thought of as linear only in a very general fashion, particularly under conditions of increasing failure or repeated exposure to the same level of failure. For instance, Shelley (1950) noted that there was little relationship between experimentally induced success and failure and Ss' perceptions of the degree of success or failure they had experienced. Further, the Ss in the success and failure conditions of his experiment could not be differentiated on the basis of their perceptions of experimentally induced success and failure.

Related research has shown that a non monotonic curvilinear relationship exists between induced success and failure and Ss' expectations for success or failure (e.g., Ford, 1963; Hilgard et al, 1940; Spector, 1956).

These findings suggest that Ss' perceptions of success and failure may show successive adaptations to the situation. Such a relationship would be predicted from the theoretical positions of Berrien & Angoff (1957) and Driver & Streufert (1965). This prediction is also paralleled by the findings of Miller (1960) with adaptation to increasing punishment. This experiment is concerned with a partial investigation of these propositions.

Subjects

The Ss used in this experiment were 14 male volunteers drawn from an introductory course in psychology. Ss received payment and bonus credit toward their course grade for participation.

Procedure

Ss were placed in a tactical and negotiations game situation (a modification of the tactical game described in Streufert, Clardy, Driver, Karlins, Schroder, & Suedfeld, 1965). They were given the task of making decisions regarding the direction of the diplomatic and tactical operations of a mythical foreign power

engaged in subduing a revolution within a small country. Ss were under the impression that they were playing against other Ss representing the revolutionary movement. However, all functions of the enemy were performed by the Es. The strategy of the supposed enemy was preprogrammed. The constant strategy and design of the mythical country assured that all Ss could be kept approximately equal in (a) the general kinds of operations which would be employed by them, (b) the types of failures which they would experience, and (c) the degree of failure which would be associated with the Ss' actions. Information load was held constant at 10 inputs per half hour session (cf., Streufert & Driver, 1965; Streufert & Schroder, in press; Streufert, Suedfeld & Driver, 1965). Half of the inputs for each period dealt with diplomatic affairs and half with tactical matters. The order of the diplomatic and tactical inputs was randomly varied across periods.

All teams were exposed to 10 sequential levels of failure (i.e., 1, 2, 3, ..., or 10 messages indicating failure). The number of messages communicating failure was increased sequentially from period 1 through period 10. The remaining messages for each period were neutral (i.e., contained relevant facts, but indicated neither success nor failure of operations). Failure was randomly varied across the tactical and diplomatic inputs for each period.

All 10 game periods were played in one evening. After each playing period was completed, Ss were instructed to fill out a "report to home country" form. (These forms were similar to the "commander reports" described in Streufert et al, 1965.) In this report, Ss were presented with two six-point scales on which they were to rate the degree of success and the degree of failure they had experienced during the preceding period. The data analysis is based on Ss' scores on these scales.

Results and Discussion

Since period 1 was used as a warm-up period to acquaint Ss with the experimental environment, the data from that period are not included in the analysis.

A within-Ss analysis of variance was used as a test of significance (Winer, 1962). There was no significant difference between ratings on the "inverted success" and "failure" scales. Further data analysis was therefore based on the failure scales. The main effect of level of failure was significant ($F=6.2258$; $p < .01$). A trend analysis of the data indicated that the linear and quintic components were significant ($F=16.9920$; $p < .01$; $F=5.8482$; $p < .05$, respectively). Seventy-six percent of the variance was accounted for by these effects.

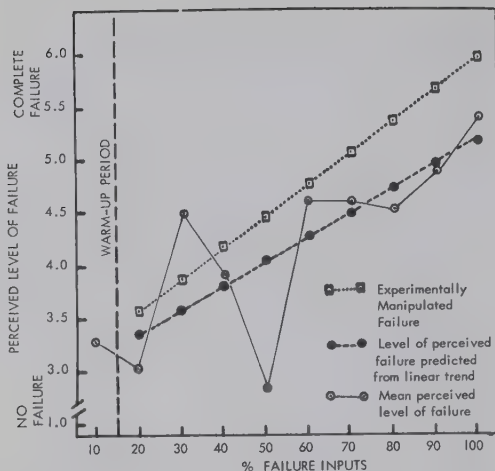


Fig. 1. A comparison of perceived and experimentally manipulated failure.

The mean perceived degree of failure at each level of induced failure is shown in Fig. 1. The differences between the means for adjacent levels of failure were compared using *t*-tests.³ The differences between levels 2 and 3, 3 and 4, 4 and 5, 5 and 6, and 9 and 10 were significant ($p < .05$).

Taken together these results indicate that although the perception of failure increased in a generally linear fashion, there were significant deviations from linearity. Further, as can be seen from Fig. 1, although the Ss' perceptions of failure generally increased with increasing induced failure, the increase in perception was less than the experimental increase. These results are similar to those found by Miller (1960) comparing the effects of gradually increasing punishment to the onset of an initially high level of punishment.

There is little possibility that the obtained results were due to the passage of time alone. Previous research (Streufert & Schroder, in press) has found no significant changes in perception of success or failure over time when the levels of experimentally induced success and failure were held constant. We may therefore conclude from the present data that there were two types of adaptation taking place: (a) A series of successive specific adaptations to particular quantities (i.e., proportions) of failure, indicated by the quintic trend, and (b) an apparent general adapta-

tion of the Ss, indicated by the differences between manipulated levels of failure and perceived levels of failure expressed by the divergence of the linear trends in Fig. 1. The first type of adaptation could be predicted from the homeostatic model of Berrien & Angoff (1957); the second from the anticipation-invigoration-mechanism of Cofer & Appley (1964). Both effects are predictable using the general incongruity adaptation level model proposed by Driver & Streufert (1965).

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Notes

1. This research was supported by the Research Council, Rutgers, The State University.
2. Douglass College.
3. Tested with the Scale by Level of failure by Ss error term having 104 degrees of freedom.

Spontaneous alternation of high and low reactively curious children

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Forty-eight fifth and sixth grade children were divided into high and low reactively curious groups on the basis of a paper and pencil reactive curiosity scale, and given a series of twenty T-maze tracing tasks. Each group was subdivided into a Constant Stimulus condition and a Varied Stimulus condition. The results showed that high reactively curious children alternated above chance level in both the Constant and Varied conditions, and low reactively curious children alternated about chance level in the Constant condition and above chance level in the Varied condition.

Ellis & Arnoult (1965) have demonstrated that stimulus novelty is a determinant of spontaneous alternation in nursery school children. In a T-maze tracing task, children alternated significantly above chance if the T-maze stimuli remained constant over 20 trials, and significantly below chance if the stimuli varied on each trial. These results would seem to be consistent with Dember and Earl's theory of alternation behavior (1957). Under the condition of nonvarying stimuli the child would be expected to alternate in order to optimize the amount of stimulus change; whereas in the varying condition, the T-maze stimuli were continuously changed and this would appear to provide enough stimulus variation without S alternating from trial to trial.

Penny & McCann (1964) have developed a reactive curiosity scale purported to measure in part individual differences in the stimulus variation seeking of children in grades four through six. One characteristic of the reactively curious child is that he seeks new, incongruous stimuli and actively varies his stimulation.

The present study determined the relationship between fifth and sixth grade children's reactive curiosity and their alternation behavior under constant or varied stimulus conditions of the T-maze tracing task used by Ellis and Arnoult.

Method

A total of 98 fifth and sixth grade children were administered the Reactive Curiosity Scale (RCS, Penney & McCann, 1964) in their classrooms. The RCS is a 90-item self-report test developed by Penney. On the basis of their RCS test scores, 24 Ss scoring highest on the RCS were placed into the High Curious group and 24 lowest scoring Ss were placed in the Low Curious group. The Ss in each of these groups were then randomly assigned to either the constant or varied stimulus condition for the T-diagram task. This task consisted of drawing lines with felt tip pens onto twenty T-mazes. Each S was brought into a room

individually and was told to draw a line down the T-alley and into one, and only one of the T-arms. When the S entered the room all twenty T-diagrams were laid out on a table but covered with a 9 x 12 piece of white construction paper. After S drew a line down the alley and into one of the arms, the T-diagram was removed and another was placed in front of him.

The T-diagrams for the constant stimulus condition consisted of black T-outlines on a white background and were marked by black felt tip pens. For the varied stimulus condition a different marker pen, T-outline, background color combination was used for each trial. The T-diagrams were 4-1/2 in. in height and width and were drawn on sheets of 4-1/2 x 6 in. construction paper. The width of the diagram was 1 in. in both vertical and the horizontal arms.

Results

Table I shows the percent of Ss alternating on each trial. A χ^2 analysis was applied to the number of alternations for each group to determine the probability of chance occurrence. The analysis revealed that the High RC Ss alternated significantly above chance on both Constant and Varied conditions (Constant: $\chi^2=4.86$; 1 df; $p < .05$. Varied: $\chi^2=10.74$; 1 df; $p < .01$). Low RC Ss alternated about chance level on Constant condition ($\chi^2=2.81$; 1 df; $p < .10$), but significantly above chance on the Varied condition ($\chi^2=17.32$; 1 df; $p < .01$).

The difference between the number of alternations in

Table 1. Percentage Alternation

Trial	HIGH RC Ss		LOW RC Ss	
	Constant	Varied	Constant	Varied
1	54	82	40	50
2	69	55	40	79
3	69	73	40	50
4	54	73	20	57
5	54	73	40	79
6	54	64	40	93
7	62	55	50	50
8	62	73	60	64
9	69	64	60	71
10	77	36	40	71
11	69	36	40	57
12	46	82	50	79
13	54	73	30	43
14	77	73	50	86
15	69	82	30	64
16	54	55	70	79
17	46	73	40	71
18	46	82	20	79
19	62	73	40	64
Mean	60.32	66.99	42.11	67.67

the Constant and Varied conditions was subjected to an F test for both High and Low RC Ss. The analysis showed that the Low RC Ss alternated significantly more in the Varied condition than in the Constant condition ($F=4.96$; 1.22 df; $p<.05$). The number of alternations for the High RC Ss was also larger in the Varied condition than in the Constant condition, but this difference was not significant ($F<1$).

Discussion

Under the condition of constant stimuli, it was predicted that High RC Ss would alternate above chance occurrence when tracing a line on the T-diagram, whereas the Low RC Ss would alternate slightly below chance. The results support these predictions and indicate that the RCS measures some attribute of a child which is later manifested on an alternation task. If, as Dember and Earl have suggested, alternation behavior is but one manifestation of a tendency of organisms to optimize the amount of stimulus change, then it seems reasonable to assume that what the RCS is, in fact, partially measuring is the amount of stimulus variation that is optimal for each child.

The results under the varied stimulus conditions are less clearcut. It had been expected, on the basis of Ellis and Arnoult's research (1965) that less alternation would be present if the stimuli were varied from trial to trial than if the stimuli remained constant throughout the trials. It also seemed reasonable, using Dember and Earl's theoretical construct, to assume that the varied stimuli would reduce the amount of alternation necessary to maintain an optimal level of stimulus change for any given S. The results do not support the predictions.

One possible explanation may lie in the instructions given the Ss before the task was begun. It will be remembered that the S was told he could draw a line to "either side." No mention was made of the possibility of alternation in order to prevent a demand characteristic. It might have been that varying stimuli from trial to trial had the effect of developing a "set" of alternating from trial to trial in the S. That is, since the stimuli were different on each trial the S may have taken this difference as a cue that it was permissible, or possibly even mandatory, that he change sides from his previous response. The Ss under the Constant condition, on the other hand, may have developed a "set" of perseveration, since each trial appeared the same as the last.

One difference between the present experiment and that of Ellis and Arnoult, is the age of the Ss. Ellis and Arnoult used nursery school children and the present study used fifth and sixth grade children. At the lower age level more varied stimulation seemed to decrease alternation, while the opposite effect is reported for older children. It might be that varied stimulation had differential effects on alternation behavior at different age levels. This possibility requires systematic study.

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The effect of asymmetric stimulation on the apparent median plane

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An experiment was conducted to determine the effects of an asymmetrical, distractor stimulus placed at varied distances from the objective median plane on the amount of shift of the apparent median plane. A non-monotonic relationship was found between degree of asymmetry and amount of shift. Although all degrees of asymmetry effected a shift in apparent median plane, the largest shift occurred when the distractor stimulus was asymmetrical by 40 degrees.

The apparent median plane (A.M.P.) may be defined as that position in space which is judged to be straight ahead. Werner & Wapner (1952) have found that when Ss are instructed to report the point at which the edge of a luminous rectangle is directly to their front, in a darkened room, the A.M.P. is displaced toward the middle of the rectangle; i.e., if they located the left edge, the A.M.P. shifted to the right, and vice versa. The authors interpreted this result as a case of "symmetrization," since the Ss' A.M.P. shifted in such a way that the visual stimulation was made more nearly symmetrical. The present investigation was conducted to study the effects on the A.M.P. of different degrees of asymmetry of visual stimulation in a darkened room. The use of a movable, cylindrical stimulus which could be placed at various angular distances from the objective median plane (the objectively measured straight ahead) made it possible to determine the functional relationship between degree of asymmetry and amount of shift of the A.M.P.

Subjects

Eighteen college sophomore students, naive as to the purpose of the study, participated as subjects in the experiment.

Apparatus

A. Target Light. A small box with a rectangular 2-1/2 in. x 2 in. opaque glass front, containing a 7-1/2 volt, 110 A.C. light bulb, was mounted on wheels in such a manner that E could roll it along the 4 in. surface of a straight track which was 6 ft. in length. To the box was attached a pointer which allowed the location of the center of the rectangular light on the track to the nearest 1/4 in. The track was calibrated in 1/4 in. from 0 on the left to 280 on the right.

B. Chair and Headrest. Eight ft. in front of the track a standard classroom desk chair was situated. A headrest was attached to the arm of the chair in such a way that it was directly in front of S. Since S had to lean forward to place his head in the rest, the track, described above, was placed on a table (30 in. high) so that the rectangular light would be approximately

at S's eye level. The center of the track was directly to the front of the seated S.

C. Asymmetric Stimulus. A vertically oriented oblong box with a rectangular 11-1/2 in. x 1 in. opaque glass front, containing a 7-1/2 volt, 110 A.C. light bulb, was movable to any point in a circular arc with a radius of 8 ft. and a height of 30 in. around the chair. The position on the arc at which this vertical light was placed determined the degree and the direction of asymmetry of the visual field. The 10 positions chosen were 30, 40, 50, 60 and 70 degrees to each side of the objective front of the chair.

The experiment was conducted in a dark room.

Method

Ss were tested one at a time. S was told to close his eyes and was then led by E into the experimental room and seated in the chair. The room was then darkened and the test lights were switched on. S was then told to open his eyes. The instructions were as follows: "Do you see the small rectangle and the cylinder of light?" All Ss answered in the affirmative. "I am going to move the small rectangle and I want you to tell me when the middle of the light is directly in front of you. Do you have any questions? I want you to close and open your eyes whenever I ask you to. Okay." All Ss seemed to understand the procedure, as they had no questions.

Each trial consisted of the following: The asymmetric stimulus was placed at one of the 10 angular positions, the target light was moved to either the far right or far left of the track, S was instructed to open his eyes, the target light was then moved slowly along the track until S reported that it was directly to his front, and finally S was instructed to close his eyes and the location of the target was recorded.

Each S made 40 judgments of the A.M.P., four with the asymmetric stimulus at each of the 10 positions (two judgments with the target light starting from the right and two judgments with it starting from the left of the track). S's eyes remained closed between trials while the cylinder and the target light were relocated. Each S was given a different order of presentations so that effects of practice, fatigue, and starting position of the target light would be counterbalanced.

Results

In order to ascertain the effects of varying degrees of asymmetric stimulation, the responses given when the vertical stimulus was on the left were subtracted from those given when it was on the right, for each angular position of the distractor. A mean difference

score was computed for each of the five angular positions of the distractor (30, 40, 50, 60 and 70 degrees) for each S. The larger the mean difference, the larger the shift of the apparent median plane. Figure 1 shows the average shift of A.M.P. for all Ss as a function of angular distance of the distractor. It can be seen that in all positions the asymmetric stimulus effected a shift in the A.M.P. The direction in each case was toward the side of asymmetric stimulation.

An analysis of variance showed that the differences

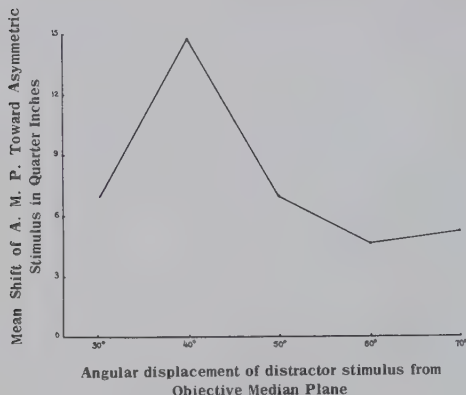


Fig. 1. Mean shift of A. M. P. as a function of degree of asymmetry.

in amount of shift between different positions of the distractor were greater than could be expected by chance ($F=6.21$, $df=4/68$, $p=.01$). Almost all of the variance between distractor positions was accounted for by position No. 2 ($SS=1131.56$), which was significantly more effective than the other four positions ($p<.001$).

Discussion

The finding that all degrees of asymmetry studied in the present investigation caused a compensating shift, or symmetrization, of the S's A.M.P. is in agreement with the findings of Werner & Wapner (1952). The shifts were always in the direction of the asymmetrical stimulus.

Figure 1 shows that the amount of shift is not monotonically related to the degree of asymmetry. The largest shift took place when the distractor light was asymmetrical by 40 degrees. It seems likely that the shift of the A.M.P. becomes greater the more asymmetrical the total visual stimulation is made, up to a point (about 50 degrees) at which the asymmetric stimulus is no longer perceived in direct relation to the target light. At that point the resultant shift is lessened.

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A supplementary study of response uncertainty and relative expected value in multiple-choice decision behavior

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Data from a previous study are reanalyzed. The study is typical 10-choice probability learning task including 1500 trials. The results demonstrate the feasibility of decomposing multiple-choice decision behavior into two distinct processes. The first process is concerned with the uncertainty of the response distribution, and the second process is concerned with the allocation of the responses to the available alternatives.

In a previous study investigating human decision strategies in a multiple-choice decision task, Messick & Rapoport (1965a) analyzed Ss' behavior in terms of the expected value, V , and the uncertainty, H , of the individual response distributions. These statistics are defined as follows for a block of m trials in which S may make any of n alternative responses on each trial:

$$(1) \quad V = \sum_{i=1}^n f(i) E_i(g),$$

and

$$(2) \quad H = -\sum_{i=1}^n [f(i) / m] \log_2 (f(i) / m).$$

In these expressions, $f(i)$ is the frequency of response with alternative i , and $E_i(g)$ is the expected gain for one response with the i th alternative. V is interpreted as a measure of the efficiency of S 's behavior within a block of m trials, and H may be taken as a measure of the predictability of S 's behavior.

In a subsequent paper (Messick & Rapoport, 1965b), multiple-choice decision behavior was conceptualized as being composed of two distinct processes, the first involving the determination of H and the second having to do with the allocation of responses to different alternatives. A measure of the efficiency of this latter process may be obtained by computing the maximum and minimum values of V for a given value of H . The details of these computations are described by Messick & Rapoport (1965b). A measure of the efficiency of the allocation process, which is independent of H , may be obtained by the ratio

$$(3) \quad R = (V' - V_{\min}) / (V_{\max} - V_{\min}),$$

where V' is some observed value of V . The range of R is the unit interval. The closer R to unity, the closer S is to maximizing his expected gain given the uncertainty of his response distribution.

The above-mentioned study investigated R as a

Table 1. Stimulus distributions for groups IV, V, and VI

Event	IV	Group V	VI
0	.01	.03	.05
1	.03	.06	.10
2	.06	.13	.17
3	.10	.10	.10
4	.12	.09	.05
5	.19	.13	.07
6	.28	.27	.29
7	.14	.12	.10
8	.06	.05	.05
9	.01	.02	.02

function of H in a task in which H was experimentally fixed. It was found that while R increased as a function of trial blocks, there was no relationship between R and H . In the present report data from a previously published experiment are analyzed with respect to the conceptualization offered by Messick & Rapoport (1965b). The study is a 10-choice probability learning task in which the predictability, H , of S 's responses is not experimentally controlled.

Method

The details of this experiment may be found in Beach & Shoenberger (1965).¹ Only a brief description of the procedure will be presented here.

The Ss were newly commissioned Naval officers, who were divided into three groups (Groups IV, V, and VI of Beach & Shoenberger, the only groups for which data were available) of 15, 13, and 13 Ss respectively. The task of S was to predict which of 10 white event lights, labelled 0 to 9, would occur on each trial. Ss were run for 1 hr. a day until they reached a total of 1500 trials. No monetary reward was given to Ss. The stimulus distributions were different for the three different groups. These stimulus distributions are presented in Table 1.

Results

The results of our analysis of the data from this study are presented in terms of blocks of 100 trials.

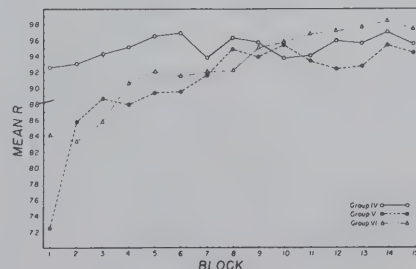


Fig. 1. Mean R for groups IV, V, and VI.

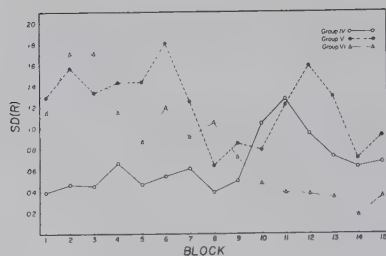


Fig. 2. Standard deviations of $\bar{R}$ for groups IV, V, and VI.

For each block the R and H statistics were computed for each S in each of the three groups. The mean R is presented in Fig. 1 as a function of trial blocks. It can be seen that the mean R increases, approaching an asymptote which is close to unity. The SD of the R measures in the three groups is shown in Fig. 2 as a function of trial blocks. While the SD tends to be somewhat erratic, there is not evidence, with the possible exception of Group IV, that it is increasing.

Figure 3 displays the mean H as a function of trial blocks. Not only does H decrease as a function of time, in addition there is no evidence that this statistic has reached an asymptote. The form of the function appears approximately linear. While the mean H decreases, the SD of the H measure shows an increase as a function of trial blocks as can be seen in Fig. 4.

Discussion

These results further demonstrate the feasibility of decomposing multiple-choice decision behavior into two distinct processes. The first of these processes is concerned with the allocation of the responses to the available alternatives. It has been shown that the efficiency of this process as measured by R , increases continuously, approaching an asymptote which is close to unity. Thus, taking the uncertainty of S 's response distribution into account, the behavior becomes nearly optimal.

However, most S s do not maximize expected gain in

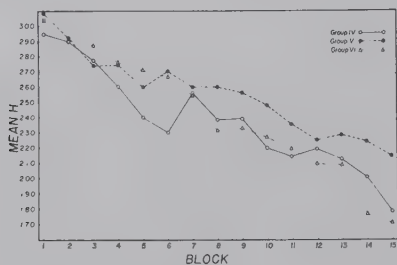


Fig. 3. Mean $\bar{H}$ for groups IV, V, and VI.

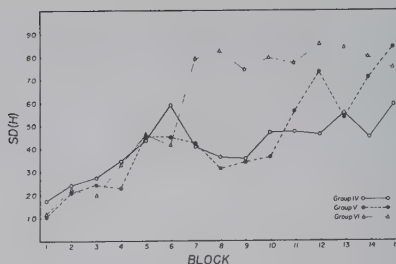


Fig. 4. Standard deviations of $\bar{H}$ for groups IV, V, and VI.

a strict sense since the response uncertainty does not go to zero. Thus, the problem of the discrepancy between actual and optimal behavior is reduced to the problem of accounting for H .

The results also indicate that, contrary to our expectations, H decreases over 1500 trials without reaching an asymptote. This finding portends difficulties for theories of choice which imply that behavior in a multiple-choice task will reach a steady state after a relatively small number of trials. With regard to the uncertainty of S 's behavior as measured by H , we find no evidence that this occurs in 1500 trials.

The data reported here tend to question even more seriously the assumption that the underlying choice process or learning process is homogeneous across S s. It was shown above that the differences between S s in H tend to increase as a function of trial blocks as reflected in the increasing SD of this measure. This fact would seem to imply that the distributions of choices for S s do not approach a common asymptote as would be expected from the models of Estes (1959) or Siegel (1959).²

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Notes

1. The authors want to thank L. R. Beach & R. W. Shoenberger for making their data available.
2. Essentially the same results were obtained from a reanalysis of the 10-choice probability learning study reported by Messick & Rapoport (1965a).

Cost and accessibility of offers as determinants of optional stopping

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In an optional stopping decision task *Ss* were presented with a random sequence of offers with a fixed cost per offer. *Ss* were instructed to maximize their gain by taking the best offer with as few observations as possible. *Ss* in group H received the highest offer observed by them, while *Ss* in group L received the last offer observed by them. Group H took more observations and made more errors than group L, though an optimal model prescribes the same behavior.

Many decision-making problems such as renting an apartment, buying a second-hand car, and selling shares of stock can be characterized as follows. The decision-maker makes a sequence of inquiries (observations) for offers and after each one of them decides whether to stop the search and take one of the offers made to him, or to continue the search. Typically, there is a cost associated with each observation which may be expressed in terms of money, effort, time spent in search, or aggravation. The decision-maker's purpose is to maximize his gain, which is determined by the offer he takes and by the cost of the search.

Assuming a fixed cost, c , per observation, and known distribution of offers, $f(z)$, an optimal solution for this class of problems is derived (Radner, 1964; Chow & Robbins, 1961). The solution is given in terms of a fixed cutoff point, z^* , on the distribution of offers, such that the decision-maker should accept the first offer greater than z^* . When $f(z)$ is known, the value of z^* is obtained from

$$(1) \int_{z^*}^{\infty} (z - z^*) f(z) dz = c$$

In the special case when $f(z)$ is a normal distribution, z^* is the value which maximizes

$$(2) \frac{f(z^*) - c}{Pr(z \geq z^*)}$$

where the values of the ordinate, $f(z^*)$, and the area, $Pr(z \geq z^*)$, are readily obtained from tables of the normal distribution. The above solution is optimal in the sense of maximizing the decision-maker's expected gain. Clearly, the value of z^* is a function of c . The higher the cost per observation, the smaller the number of observations that should be made.

In some of the above decision situations the decision-maker is able to accept only the last offer made to him. He has no access to the previous offers he observed. In other decision situations all the offers observed remain available to the decision-maker, who may choose the highest among them. Psychologically, the two kinds of situations seem different. One would expect a decision-maker to make more observa-

tions when all offers remain accessible than when any offer not accepted is immediately lost. The optimal model, however, prescribes the same behavior for both decision situations. Since the optimal solution is to accept the first offer above the cutoff point, the accessibility of past offers is irrelevant.

Method

Ss were 30 male students from the University of Michigan who volunteered to participate in a paid computer-controlled task. Each *S* served individually for one experimental session.

Each *S* was seated in front of an LGP-30 computer with a Friden flexowriter connected to it, and given a set of written instructions. *S* was asked to act as a company representative who wanted to sell some shares of stock. At each trial the computer printed an offer from a different agency and *S* decided whether to sell the shares, by typing "sell" on the flexowriter or to ask for another offer, by pressing the appropriate key. There was no limit on the number of offers the computer could make.

Ss were divided randomly into two equal groups. *Ss* in the group H were told that they could sell the shares at any time for the highest offer made to them so far. *Ss* in group L were told that they could sell the shares at any time for the last offer made to them. All *Ss* were told that each offer cost a fixed amount, c , which was the fee charged by each agency.

The offers were randomly selected from a normal distribution with mean \$1800 and standard deviation \$300. Each *S* was presented with 29 separate problems, differing in the cost per offer. There were four cost conditions. The cost was \$5, \$20, \$10, and \$35 for problems 1 through 8, 9 through 15, 16 through 22, and 23 through 29 respectively. The company's pay-off, g , for each problem was given by $g = z' - n c$, where n is the number of offers made, and z' is the highest or last offer made to *Ss* in group H or L respectively. The value of g was printed at the end of each problem. The first problem was for practice only. Each *S* observed 20 offers to provide him with initial information about $f(z)$.

A single sequence of offers for all problems was randomly devised and presented to all *Ss*. Since each *S* determined the number of observations for each problem, different *Ss* observed the same offers on different problems (except for problem 1). *Ss* had to ask for at least one offer for each problem. They were instructed to maximize the company's total gain. Their gain for the experiment, G , was given by

$$(3) G = \frac{\sum g_i}{300} \text{ (in cents), } i = 2, 3, \dots, 29$$

Results and Discussion

The mean gain for both groups under the four cost conditions (5, 10, 20, and 35, in that order) was 2316.4, 2209.2, 2193.7, and 2012.9 for group H, and 2265.5, 2256.6, 2147.5, and 2027.3 for group L. As predicted by the model the mean gain for both groups decreased with an increase in c . The overall difference between the mean gains of the two groups was not significant ($p < .05$).

The mean number of observations, n , for both groups under the four cost conditions was 15.57, 12.22, 8.15, and 5.48 for group H, and 11.78, 9.28, 6.61, and 5.82 for group L. The optimal number of expected

observations for each value of c , n^* , was 25.00, 13.65, 7.40, and 4.75 for the 5, 10, 20, and 35 cost conditions respectively. The value of n^* is obtained from

$$(4) \quad n^* = \frac{1}{P(r \geq z^*)}$$

for a random sequence drawn from a normal distribution with the given mean and variance, rather than for the particular sequence used. Since for any given problem different Ss received different offers, there is no single sequence for which the optimal number of observations can be obtained for all Ss.

The mean number of observations for both groups decreased as the value of c increased. Similar results were obtained by Lanzetta & Kanareff (1962) and by Irwin & Smith (1957), using a similar decision task and two different costs per observation. As hypothesized above, group H observed more than group L. The overall difference between the two groups is significant ($p < .05$).

As c increases, the difference between the two groups with respect to n tends to disappear. Comparing the values of n to n^* for both groups, it is evident that both groups observed less than prescribed by the model for the low cost, and approached the predicted n^* as the cost per observation increased.

The optimal model prescribed taking the first offer greater than a chosen cutoff point. Whenever S terminated his observations at a different offer, he violated the cutoff point model. This is the case whether the cutoff point is chosen optimally or not. Moreover, the above holds even if each S is allowed to have a different cutoff point and to change it from one problem to another, even within a cost condition. This is the weakest form of a cutoff point model which allows learning from one problem to another.

In order to test this weak version of the cutoff point model, the number of observations after the highest offer (errors) was computed for each S for each problem. The mean number of errors, e , under the four cost conditions was 6.30, 3.79, 2.60, and 1.50 for

group H, and 2.54, 1.67, 1.79, and .50 for group L. With the exception of one data point, the values of e decrease as c increases, approaching the predicted value from any cutoff point model, i.e., $e = 0$.

The value of e is higher for group H than for group L for all cost conditions. The difference between the groups decreases as the value of c increases. The overall difference in e between the two groups is significant ($p < .05$). This result indicates that the inaccessibility of previous offers resulted in closer agreement with a cutoff point model. The difference in e between the two groups may be explained by the fact that errors were more costly for group L than for group H. If an S in group H failed to accept a high offer, which turned out to be the highest offer for a particular problem, he could still receive it minus the cost of the additional observations. For an S in group L such a failure would result in a greater loss, since this offer would not remain accessible.

In spite of the significant differences between the two groups with respect to n and e , no significant difference in G was found. This is accounted for by the compensatory effects of the discrepancies of both groups from optimality with respect to n and e . While group H was closer to the model than group L in terms of n , group L was closer to the model than group H in terms of e . Both of these discrepancies decreased as a function of the cost per observation.

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Problem solving within a verbal response hierarchy¹

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Upon being given a stimulus word, Ss were given three guesses to discover the strongest or the second strongest associate of the word. As expected from response-hierarchy approach to problem solving, improvement over successive guesses was greater for the weaker associate.

Response hierarchy approach to problem solving (Maltzman, 1955) would suggest that if the solution response is high in the hierarchy of responses elicited by the problem stimulus, S's first guess at the solution response will more likely be correct than if the solution is lower in the hierarchy. But if the first guess is incorrect and S is allowed to make additional guesses, such subsequent guesses should be of responses lower in the hierarchy. Therefore, measured by the first guess alone, performance should be better if the response to be discovered is high in the hierarchy than if it is low. However, on subsequent guesses, this difference should be reduced; there should be a relatively greater gain in performance on the low-hierarchy response. In addition to testing this notion, the present experiment includes a measure of directionality of associations in a guessing situation.

Method

The materials were 20 Kent-Rosanoff stimulus words, plus the first (strongest) and the second associate for each stimulus, all taken from the Russell & Jenkins norms (1954). For some of the items, the strength of the first associate is relatively high, for others, relatively low.

E said to S, "I want you to try to guess a word that I am thinking of. I will give you a word that is associated with the word I'm thinking of, and then you try to guess the word. I will let you have three guesses. All right, the word that is associated with the word I'm thinking of is..."

For all Ss in both Group 1 and Group 2, E gave S the Kent-Rosanoff stimulus word for all 20 items. For Group 1 Ss, the first associate was the word to be guessed. In Group 2, the second associate was correct. If S got the correct word before taking three guesses, E went on to the next item. If S did not get the correct word in three guesses, he was not told the word. For every item, E said, "The associated word is...", or, "The associate is..." The 20 items were arranged in five different random orders which were assigned to Ss in turn.

Group 1 and Group 2 each contained 50 Ss. An additional group of 50 Ss, Group S, was given the first associate for each item and allowed three attempts to guess the stimulus word. Comparison of Group

S with Group 1 provides information on the role of directionality of associations in a response discovery situation.

Results and Discussion

Since the expectation was that Groups 1 and 2 would show differing patterns of performance from the first guess to subsequent guesses, two scores were obtained for each S. One was the number correct on the first guess. The other was the sum of the number correct on the second and third guesses combined. For Group 1, the mean correct on the first guess was 8.82, the mean on guesses two and three was 4.20. For Group 2, the mean on guess one was 2.94, the mean on guesses two and three was 4.62. Thus, as expected, relative to the first guess, the performance of Group 2 improves on later guesses. The interaction of groups $\times$ guesses suggested by the four means is highly significant, F was 142.9, p .001 with 1 and 98 df. As can be seen, even though Group 1 had a much higher mean than Group 2 on the first guess, Group 2 did slightly better than Group 1 on later guesses.

When S is asked to guess a word that is associated with some given word, it is not clear whether S treats the given word as a stimulus which elicits an associate that he is to guess, or whether he treats the given word as an associate whose stimulus he must guess. Comparison of Group 1 (given the Kent-Rosanoff stimulus word, guess the first associate) with Group S (given the first associate, guess the stimulus) provides evidence on this point. Over all 20 items, these groups did not differ. Mean correct first guesses were 8.82 for Group 1, 9.24 for Group S. Mean total correct guesses (after three guesses) were 13.02 for Group 1, 11.98 for Group S. Neither of these mean differences is significant. Examination of individual items revealed that for many of them, the stimulus and its strongest associate were strongly and equally associated in both directions, measured by number correct over all three guesses. These were usually opposites such as sweet-sour. Others were mediumly and equally associated, e.g., wish-want. Strong unidirectional associates were river-water, and stomach-food; the stimulus (first word) elicited the associate but rarely vice versa. In two items, whistle-stop, and citizen-U.S.A., there was little evidence, by the guessing method used in this study, of association in either direction.

The results suggest that if S is trying to discover the solution response to a problem, his successive guesses tend to follow a response hierarchy pattern. Several consequences follow. If the solution response

is very high in the hierarchy, many, though not all, first guesses will be correct. Subsequent guesses are not likely to increase greatly the total number of correct responses since such guesses should tend to be of responses lower in the hierarchy, which is not conducive to discovering a high-hierarchy response. However, if the solution response is a low-hierarchy response, first guesses should infrequently be correct, but performance should improve, relatively, on later guesses.

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Note

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Response alternation in children under different schedules of reinforcement¹

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A group of 7 to 9 yr. old children were tested in a two-choice situation under 100%, 67% alternating, 50% alternating or 50% random schedules of reward regardless of the choice they made. Continuous reward resulted in significantly more alternating responses than any of the partial reward conditions. The ratio of reward to nonreward or the regularity of the schedule had no effect on frequency of alternation. Significantly more alternating responses were made on trials following nonreward.

The response alternation of rats in two-choice situations has been ascribed to the inhibitory effects of stimulus satiation (Glanzer, 1953) and the motivational properties of novelty seeking (Berlyne, 1960). In an attempt to differentially test these two hypotheses, Ellis & Arnoult (1965) asked nursery school children to trace paper T-mazes with crayons. For half the Ss the colors of the crayons, outline and background varied, while for the other half they were kept constant. Fewer response alternations were found under conditions of varied stimulation, providing supportive evidence for Berlyne's hypothesis that alternation stems from a curiosity drive.

In reviewing a number of other studies of alternation in humans, Schultz (1964) proposes that those findings also are compatible with the view that alternation is the result of a need for stimulus variation. There are, however, some recent findings which are difficult to explain in terms of stimulus variation seeking. Jeffrey & Cohen (1965) studied the behavior of children in a two-choice situation and reported that with 100% reward 3 yr. olds alternated, on the average, only 1.5% of their responses, while 4-1/2 yr. olds alternated 76% of the time. When exposed to partial reward, the older children alternated less frequently but the younger ones increased their alternations. For 4 yr. olds the greater frequency of alternation under continuous reward can be handled by a curiosity drive notion because continuous reward results in a more consistent level of stimulation and a consequent heightening of the drive. However, without assuming that 3 yr. olds are less curious than 4 yr. olds, there is a problem in accounting for the almost complete lack of alternation by 3 yr. olds who are continuously rewarded.

The present study utilizes a test situation similar to the one employed by Jeffrey & Cohen in an attempt to explore the response tendencies of an older group of children under four different reward schedules.

Method

Sixty children between 7 and 9 years of age from second grade classes in the Northeast Houston Independent School District were used as Ss. The apparatus consisted of a lazy susan tray mounted in a box so that half of it protruded through a slot while the other half was concealed. The tray, 18 in. diameter, contained 2 pairs of identical 3.5 in. square gray blocks, each covering a hole in which M & M candies could be placed. The blocks lay side by side with a 5 in. space between them. On any given trial one of the pairs was exposed to S while the other pair was in the box being reloaded by E.

Ss were assigned randomly to one of four groups differing in the reward schedule. In all cases reward was independent of the particular choice made. For one of the groups (100%) a candy was always concealed under both blocks and those Ss received a reward on every trial. The second group (50%A) received a reward on a random 50% of the trials. The third group (50%R) received a reward on a random 50% of the trials. A 67% alternating schedule was employed with the fourth group (67%A); choices made on every third trial were non-reinforced.

The Ss were tested one at a time and all were given identical instructions. They were told to choose the block they thought was correct and if they were right there would be an M & M candy under it which they could keep. There was a total of 40 trials; the first one was rewarded for all Ss.

Results

Table 1 gives the mean per cent of alternating responses on all trials for each of the four groups. Considerably more alternations were found with the 100% group and there was very little difference among the three partial groups. Separate t tests comparing the 100% group with 67%A, 50%A, and 50%R indicated that each of the partial groups made significantly fewer alternating responses ($t=2.29, 2.38, \text{ and } 2.91$;

Table 1. Average Per Cent Alternating Responses

Groups	All Trials	Following Reward	Following Nonreward
100%	72.7	72.7	---
67%A	55.4	53.7	58.7
50%A	55.1	50.2*	60.1*
50%R	54.0	48.6*	59.3*

* In order to provide comparisons based on an equal number of trials following reward and nonreward, the last trial (trial 40) was dropped in calculating these averages.

$p < .05$, $.05$, and $.01$, respectively).

Also contained in Table 1 is a comparison of the frequency of alternating responses following a rewarded trial and following a nonrewarded trial. Under all three conditions of partial reward, alternation was more frequent on trials following nonreward. A t test comparing the relative number of alternations on the two kinds of trials for the three groups combined indicated that this finding was reliable ($t = 2.56$; $p < .05$).

Discussion

Under conditions of 100% reward, Jeffrey & Cohen (1965) found a large difference in the tendency to alternate when 4-1/2 yr. olds were compared with 3 yr. olds. Schusterman (1963) also reported a very strong tendency for 3 yr. olds to perseverate while 5 yr. olds alternated at a significantly greater than chance level. On the other hand, 10 yr. olds showed no preference for either response pattern. Taking the present data into account it appears that a preference for alternation begins at about 4 years of age, persists through age 8, and drops out by age 10.

In attempting to account for the age difference within the framework of a curiosity drive hypothesis, Schusterman (1963) concludes that within a certain age range children display a great desire for stimulus change, particularly under conditions of relatively constant stimulation. One test of the effect of stimulus constancy on alternating behavior within this age group is provided by comparison of 50%A with 50%R. The stimulus conditions are more constant under alternating than under random reward and the former should result in a greater degree of alternation. Table 1 indicates, however, that the percent alternations are essentially identical under the two schedules.

The 67%A condition was included in this study because of the report by Weir (1964) that alternation was affected by the percentage of reward. Using a three-choice situation in which responses to only one level were rewarded on a 33% or 67% schedule, he found that 67% resulted in less pattern responding (left, middle, right or right, middle, left). In the present study the results with 67%A did not differ from 50%A or 50%R, indicating that the particular schedule employed was not

directly related to the degree of alternation. Weir's findings may be due to the fact that in his task perseveration on the partially reinforced level was an optimal response pattern. Presumably this was more apparent when the pattern yielded 67% rather than 33% reinforcement.

Attempts to account for alternation behavior have generally focused on stimulus variables. The reports of developmental differences suggest that response sets and cognitive factors play an important role as well. While perseveration appears to be the dominant response set below the age of 4, Ss in the age group studied here start with a set to alternate. Under 100% reward this set was reinforced and continued. With partial reward and instructions to find the candy every time, alternation was not reinforced and other sets or hypotheses replaced it, dropping the per cent alternation to nearly the level expected by chance. What excess there was above the chance level occurred on trials following nonreinforcement. This may have resulted from the abandonment of positional hypotheses when they met with nonreward. The ratio of reward to nonreward or the regularity of the schedule appears to have had no effect on the response patterns displayed by these children.

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Note

1. The cooperation of G. C. Scarbrough, Superintendent, Northeast Houston Independent School District, and George E. Moore, Principal of Ponwood Elementary School, is gratefully appreciated.

Effect of contextual meaningfulness on the rated meaningfulness and recall of words¹

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In three lists containing the same subset of 15 standard words of medium rated meaningfulness (m') and 15 context words of varying m' , recall of the context words increased directly with their m' . Recall of the standard words did not vary reliably, but tended to be most affected by contextual meaningfulness under number-assignment instructions under which recall increased with the m' of the context items. In contrast to the tendency toward a direct variation of recall with contextual m' , the m' of the standard words was found to vary inversely with the m' of the context words, replicating Amster & Battig (1965).

In an earlier study (Amster & Battig, 1965), verbal contexts which varied in meaningfulness were found to affect both rated meaningfulness (m') and associative productivity (m) of a standard subset of items within the lists, but expected effects of contextual meaningfulness on recall were not observed. The present experiment constitutes a further study of contextual effects on recall, and also permits replication of the earlier results on m' . Contextual m' was expected to affect the free recall of other items within the list, but might depend on the type of instructional set employed. Amster & Battig (1965) found increased contextual m' to decrease the m' of standard words while it facilitated m . These conditions of contextual m' enable determining whether recall is dependent on rated or actual meaningfulness, i.e., if recall is dependent on m , the recall of a subset of items should be improved under the contextual conditions which increase the m of these items. If dependent on m' , recall should be improved under the opposite conditions.

A subset of standard items appeared in three lists differing with respect to the m' of the other (contextual) items. Recall followed m' ratings or a condition in which the same words were rated for evaluative connotation or were assigned numbers with no basis specified by E. Amster & Battig (1965) may have failed to find significant recall results because of the prior task, to produce associations to the words in the list. These associations may have been strengthened by virtue of their overt verbalization and could have constituted interference at recall. This explanation is consistent with an earlier failure to find facilitation in recall following the production of associations (Mandler & Campbell, 1957). The present experiment also controlled for pleasantness, known to affect recall (Amster, 1964), and item order.

METHOD

Subjects

The 108 Ss included 63 elementary psychology students from Contra Costa Junior College, and 45 educational-psychology students at the University of California at Berkeley. Additional Ss were randomly discarded so that the 12 Ss in each condition included equal proportions of seven and five from the respective student populations.

Design

The nine conditions represented a 3 by 3 factorial design with the three types of rating instructions (m' , pleasantness, and unspecified assignment of numbers) combined with the three lists varying in contextual m' . All lists contained the same 15 standard words of medium m' and 15 context words which were either relatively high, medium, or low in m' . Four different orders within the list were each used for an equal number of Ss. For each order the standard words were presented in the same ordinal position for each of the three lists.

Materials

Prior to the experiment, the 60 CVC words used by Amster & Battig (1965) along with 60 additional CVC words of comparable m' levels, were rated for pleasantness on a nine-point scale by 30 educational-psychology students at the University of California at Berkeley. One set of 15 standard words with a median m' value of 3.54 and 15-word sets of higher (4.21), equal (3.53), and lower (2.95) m' context words, which were equated and highly homogeneous in neutral evaluative connotations were selected.

Procedure

All Ss were tested in intact classes, with all nine conditions administered in every class. Each S was given a small spiral notebook to be used for his ratings, along with a three-page booklet containing instructions, a list of words appropriate to his conditions, and a response sheet for recall.

For the m' rating, S rated each word as the "number of things or ideas which it makes you think of," on a scale ranging from none(1) to very very many(7). For the evaluative rating, Ss were asked "to rate each word as to how pleasant it is" on a scale from very very unpleasant (1) to very very pleasant (7). For the number control, Ss were told "to simply write down a number from one to seven next to each word" and that "there is no right or wrong about it." Ss were further instructed to record the time when they finished their ratings and then to study the words in preparation for the recall test in which "you will be asked to write down the ones you remember." After the 7.5 min. allotted for the rating task, the Ss were given 5 min. to record as many words from the list as they could in whatever order they came to mind and not to try to write the words in a space corresponding to its position in the original list.

RESULTS

An analysis of variance of the ratings (see Table 1) in the m' and number-assignment conditions revealed a significant interaction of Context List with Word Type (standard or context), $F=10.39$, $df=2/66$, $p<.01$, and an interaction of these variables with Instruction, $F=9.34$, $df=2/66$, $p<.01$. The latter reflects the absence of any consistent effect of either List or Word Type under the number-assignment condition. However, replicating Amster & Battig (1965), standard words were rated reliably lower in the high m' context than in the low m' context. According to the Scheffe contrast, mean differences (Table 1) as great as .56 are sig-

Table 1. Mean Ratings of Standard and Context words in Three Lists under Meaningfulness Instructions

Type of word	High m'	Medium m'	Low m'
Standard	3.14	3.87	4.13
Context	4.18	3.96	3.23

nificant beyond the .05 level. A similar analysis for the pleasantness and number-assignment conditions revealed only that significantly larger numbers were used for rated pleasantness (2.14) than number-assignment (1.97), $F=5.34$, $df=1/66$, $p < .05$.

As shown by the overall means in Table 2, recall of the context words varied directly with their m' but the corresponding variation in recall of standard words was not consistent, producing a significant interaction between these two variables, $F=3.13$, $df=2/72$, $p < .05$. Recall of the standard words varied directly with contextual m' under the number-assignment condition, but deviated from this pattern under pleasantness instructions. Although the triple interaction was n.s., a more stringent test, an analysis of the recall of standard words only, revealed a trend ($F=2.16$, $df=4/99$, $p < .10$) toward an interaction between Instructions and List.

DISCUSSION

Although context words were selected for m', they varied similarly in m. As expected, recall of the context words increased with their m' (m) under all instructions, but surprisingly, not only were the differences in recall of context words most pronounced under the number control condition, but also, the differences among standard words were most pronounced. The trend of the means for this condition suggests that the greater the m' (or m) of the context words, the better the recall of the standard words. An ad hoc explanation may be that the pleasantness and m' instructions affected the elicitation of associa-

tions and the manner in which they are used as mediators during learning. Number-assignment might interfere less with spontaneous associative activity, and being less demanding a task may permit greater deployment of mediation during learning. Also, interitem associative links could vary directly with the number of context words recalled. This could be tested by providing the context words at the time of recall and requesting recall of the standard words.

The results support the dependence of recall on m rather than m'. If recall of standard words varies appreciably with contextual m (m'), it varies directly as does m, while the m' of standard words varies inversely with contextual m (m'). On this basis, contextual m rather than contextual m' may be assumed to influence recall when and if there is a direct effect.

The overall level of recall in the present study was higher than that found by Amster & Battig (1965). This may be due to sampling factors, differing time arrangements during learning, or task factors, e.g., in the prior experiment, associations which were produced to the stimulus words may have competed with them at the time of recall, serving to reduce recall.

The differences in m' among the contextual items were smaller than they were in the former study, which could account for the small effects on recall. However, prior rating results were replicated except that the variability of the standard words was not affected by the context. As found by Amster & Battig (1965), ratings of the context words varied directly with their m', but the ratings of the standard words varied inversely with the m' of the context words, comprising a contrast effect which is consistent with Adaptation Level Theory (Helson, 1964), and analogous to that observed for judgments of verbal pleasantness (Amster, 1964).

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Note

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Table 2. Mean Number of Standard and Context Words Recalled in Each List Under Each Instruction

Type of Word	High	List	
		Medium	Low
Rated Pleasantness			
Standard	7.33	9.42	8.17
Context	8.92	8.67	8.41
Rated Meaningfulness			
Standard	7.67	8.00	8.75
Context	8.41	7.92	7.25
Number Assignment			
Standard	8.67	7.08	6.42
Context	9.00	8.08	6.25
Overall			
Standard	7.89	8.17	7.78
Context	8.78	8.22	7.30

Short-term memory in children as a function of display size¹

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Display size was varied in a card-guessing game with young children by presenting either 3, 4 or 5 animal cards in serial order, and testing for recall on one of the cards. Marked recency effects were observed at all stages of training, and during the early trials, some primacy was noted. Retrieval appeared to be an all-or-none phenomenon, in contrast to previous studies with 8-item displays, which found generalization and above-chance guessing on the second choice.

Recent studies by Atkinson et al (1964) and Hansen (1965) have used a card-guessing game to investigate short-term memory (STM) processes in young children. In this technique, a series of cards with colored drawings of animals are presented one at a time in serial order. Each card, after being presented to the child, is turned face down so that a horizontal array is formed. The child is then shown a separate cue card, and is asked to turn over the matching card in the face-down array. In both of the studies referred to above, an 8-card list was used.

A pronounced recency effect was evident in the Atkinson et al study (the last card laid down had the highest probability of being chosen correctly as a match), but no primacy was observed. Generalization effects were also found; when an error was made, the incorrect choice tended to be close to the correct position. In the Hansen study, presentation rate was varied (1 sec. and 3 sec.) with the result that the slower rate improved recall of the last cards presented, and the faster rate improved recall of the first cards. Marked recency effects were observed with both rates. There was also a slight primacy effect, especially at the slower rate.

The present study was designed to investigate the effects of within-subject variation in list length on STM of preschool children using a similar experimental task. Also of interest was the question of whether primacy and recency effects varied over trials. Murdock (1964) has shown that significant changes in the shape of the serial position curve over trials may occur when repeated measures are used in STM studies. He found primacy as well as recency during early trials, but the primacy disappeared in the later stages of training.

Method

The Ss were 38 preschool children between 3.5 and 5 years of age ($\bar{X}=4.1$, $SD=.51$) from the Unitarian Society Nursery School, Madison, Wisconsin. Each child was asked if he would like to play a game; if the child was willing, he was brought to the experimental room. There he was shown a collection of small toys, and told that

he might choose one toy as a prize for playing the game well. All Ss received the toy of their choice at the end of the session.

The stimulus materials consisted of a set of 11 brightly colored animal cards. Each card was shown to S, who was asked to name the animal until S was familiar with each card in the deck. The experiment consisted of 24 trials, each trial requiring about 1 min., for a total session time of about 1/2 hr.

On each trial a subset of 3, 4 or 5 cards was randomly selected for presentation. The randomization for a child was arranged so that each display size was used for 8 trials, and each serial position was tested at least once for every display size. The selected cards were shown one at a time to S for a 1-sec. interval, S called out the name of the animal, and then the card was placed face-down in a horizontal array in front of S. After the last card was presented, a cue card which was identical to one member of the presentation set was held up, and S was asked to turn up the matching card in the array. If the response was incorrect, S continued to turn up additional cards until a match was obtained. The intertrial interval was about 40 sec., during which time E arranged cards for the next trial and chatted with S.

Results and Discussion

Figure 1 presents the mean proportion of correct responses at each position for the three display sizes. Position 1 corresponds to the last card displayed prior to the retention test. The proportion of correct responses is a decreasing function of the number of cards intervening between the test position and recall. The probability that the last card in the display is correctly identified when it is the test position varies between .85 and .90, and appears to be unrelated to display size. It may be that this performance represents the best obtainable with preschool children in this task. Hansen's 5 yr. olds gave about .65 correct responses at Position 1 with an 8-item list, and the corresponding value in the Atkinson et al study was about .90. The proportion of correct responses in Position 2, the

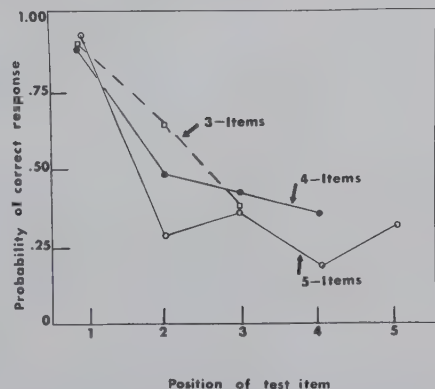


Fig. 1. Proportion of items correctly recalled on first attempt at each serial position for three display sizes.

Table 1. Frequency of first response in each position for each test position and error frequency distributions for three display sizes.

First Response	1	Test Position				Total Errors
		2	3	4	5	
3 - Item List						
1	93	12	10	—	—	22
2	12	72	61	—	—	73
3	4	22	42	—	—	26
4 - Item List						
1	71	14	4	4	—	22
2	7	40	32	16	—	45
3	2	16	35	33	—	51
4	3	11	11	29	—	25
5 - Item List						
1	62	9	8	5	1	23
2	3	23	15	14	6	38
3	1	25	25	23	26	101
4	1	8	12	13	8	42
5	0	2	6	10	22	18

next-to-last card presented, varies from .34 to .67, and is monotonically related to display size. As the display size is decreased (i.e., as fewer cards are presented), S is more likely to recall the card presented in Position 2, and the amount of this improvement is greater than can be accounted for by changes in the guessing rate.

The number of times each position was the first choice at each test position is presented in Table 1 for the three display sizes. Investigation of these data indicates that, unlike Atkinson's study, no generalization around the correct position was observed. Rather, there was a tendency at all display sizes to choose one of the middle cards in the array when an error occurred.

Since there appeared to be no generalization with the relatively small display sizes used in this study, the hypothesis was entertained that, when the cue card was presented, either the child was able to retrieve the position of the matching card from a short-term store, or else the child simply guessed at random according to the non-uniform marginal distribution in Table 1. The following analysis was carried out with this hypothesis in mind. In Table 2 is presented the mean number of cards turned up before a correct match was obtained at each test position, based on those

Table 2. Mean number of cards turned up before a correct match, given that the first response was an error, observed and predicted (in parentheses).

List Length	1	2	3	4	5
3	2.69	2.12	2.30	—	—
	(2.65)	(2.25)	(2.53)		
4	3.00	2.56	2.45	3.12	—
	(3.14)	(2.58)	(2.70)	(3.18)	
5	3.60	3.07	2.71	2.81	3.68
	(3.62)	(3.31)	(2.80)	(3.55)	(3.98)

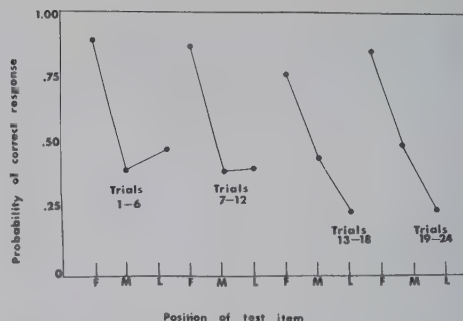


Fig. 2. Serial position curves in 6-trial blocks over display sizes for first (F), last (L), and all middle (M) test positions.

trials when the first response was incorrect. The predicted values are obtained from the all-or-none retrieval hypothesis mentioned above, and the empirical error distributions in Table 1. (The probabilities were renormalized as cards were drawn successively.) The predicted values in Table 2 give a reasonably good account of the observed data. If there is any noticeable trend to the discrepancies, the predicted values tend to be slightly higher than the observed, which might indicate that the subject may occasionally have some idea about the correct position, even though the first response is wrong. This interpretation would accord with the finding of both Atkinson et al and Hansen that the second choice, following an initial error, tends to be correct more frequently than chance would predict.

In order to evaluate changes in the serial position curve over trials, the probability of an initial correct choice was found for the first (F) and last (L) positions, and for all middle (M) positions taken together, averaged over display sizes in 6-trial blocks. The results of this analysis, presented in Fig. 2, are in agreement with Murdock's (1964) results; primacy as well as recency is observed during the first two blocks, following which there is only recency.

Comparison of the present study with the results of Atkinson et al and Hansen indicates that children may process long and short lists in somewhat different ways; additional information will have to be obtained by within-subject variation of list length over a wider range in order to specify these differences.

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Note

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GSR conditioning at a long CS-US interval mediated by S's counting behavior

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When S counted during each 5.0 sec. interval between the external CS and US, extinction GSRs occurred shortly after the end of counting but not shortly after the CS. Discussion suggests trace conditioning of startle, alimentary, heart beat and inspiration cycles may be mediated by analogous orienting responses and reflexes.

Although the expectation that trace conditioning is mediated by a chain of behavior has a history almost as long as the trace conditioning procedure itself, no significant increase occurred in magnitude of GSR elicited by a CS after a series of CS-US intervals during which Ss had been instructed to say "1001, 1002," though significant conditioning did occur when comparable Ss had been instructed to relax (Coppock, 1965). The present study employs a longer CS-US interval and evaluates the possibilities that in the previous study vocalization interfered with the reception of the CS and/or delayed the response.

The response-produced stimuli from vocalization might account for the small extinction GSRs. The extinction GSR elicited by a stimulus was small if it had been followed, during conditioning trials, by a second stimulus in another modality, which had in turn been followed by shock (Wickens, 1965). This explanation requires the assumption that the vocal reaction times were about .2 sec., since there is no masking of the effects of the onset of the first stimulation if the second stimulation starts between .2 and .6 sec. later (Wickens, 1965, Figs. 16-4 & 16-5). Since masking of CS by onset of vocalization should occur independently of CS-US interval, a test for masking was provided by conditioning at a CS-US interval too short to require any presumed mediation by a vocal process. One new group of Ss has been instructed to relax, and one has been instructed to count during a .7 sec. CS-US interval.

In a further attempt to demonstrate mediation by vocalization, the ratio of counting trace magnitude to CS trace magnitude has been increased by two changes: The CS has been reduced in extensity and the CS-US interval has been extended from 2.0 to 5.0 sec. The longer CS-US interval also provided the occasion for an additional measurement: Conditioned GSRs might occur *after* the CS-US interval as a consequence of inhibition of delay, as second interval responses (Grings, 1965) or as anticipatory responses (McDonald & Johnson, 1965), even though these phenomena typically appear only after many conditioning trials. On the other hand, when a series of

separate stimuli such as separate numbers precede the shock, conditioned GSRs may first appear after the usual time of the US and move forward in time only as a consequence of additional conditioning trials. In either case, CRs might occur after a 5.0 sec. CS-US interval, even if in the previous experiment it was reported that the GSRs starting within 1.0 to 4.0 sec. of the CS onset included "all responses around the time of the CS."

Method

None of the 32 volunteer Ss were psychology majors. They were told that "the pointer (on a voltmeter in front of S) would move to the right 'like this' at times during the experiment." One quarter of the Ss were then told that "Each time you see it start to move you are to say 'one'. Is that clear now (Repeat)." One quarter of the Ss were told "Each time you see it start to move you are to count '1001, 1002, 1003, 1004, 1005' at just about that speed. Let's practice it. You count and I'll time you." (S was told to go faster or slower, and given practice as necessary to meet the criterion of finishing with 4-6 sec.) The remaining 16 Ss were told "...Please watch the pointer as long as the (room) light is on, and remain quiet until I give you further instruction."

The procedure consisted of explaining that a mild shock would be used, giving 2 electric shocks of 2 sec. duration, and of an intensity S would tolerate to the 3rd and 5th fingers of the right hand, then proceeding with the sequence of 3 adaptation, 2 conditioning, and 3 extinction trials which was employed in the previous experiments (Coppock, 1965). The room light was on during the first 45.0 sec. of each successive minute, and the CS of needle displacement was presented sometime during the middle 15.0 sec. of each illuminated period. During the conditioning trials, E presented shock either .5 sec. after he said "one" or "five," or .7 or 5.0 sec. after the CS, in the counting and relaxing treatments, respectively.

The first decrease in resistance starting between 1 and 4 sec. after each CS was converted to per cent change in resistance, and net change from last adaptation to first extinction trial was computed, as in the previous experiments. GSRs starting after the (presumed) end of counting were similarly measured.

Results

Mean changes in magnitude of GSR during the conditioning trials are presented in Table 1. A significant gain occurred in the 5.0 sec. counting group; not, however, in the mean GSR elicited by the CS

Table 1. Change in mean GSR magnitude during conditioning with instructions to count and to relax

CS-US Interval	.7	5.0	
Latencies	1 to 4	1 to 4	6 to 9
Counting	1.0*	.1	2.2*
Relaxing	1.4	.5	.0

* $p < .05$ by t for correlated measures; $p < .01$ after a log transformation reduced skewness.

(Table 1, next to last column), but only in the mean GSR starting 6 to 9 sec. after the CS, presumably 1 to 4 sec. after the end of the counting (last column).

The increase in GSR magnitude at the shorter CS-US interval under instructions to relax, while not statistically significant, was in the direction of conditioning and hence not inconsistent with previously reported conditioning at a .5 sec. CS-US interval.

Discussion

The previous lack of CRs after conditioning trials with 2.0 sec. CS-US interval is attributed to the continuation of counting, and this interference seems to be confined to an intermediate range of CS-US intervals. This interference may be absent when the mediating activity is similar to the UR.

The results are consistent with the hypothesis that conditioning only occurs when the US occurs within about 2.5 sec. after some change in the sensory input due to CS or a mediating response. Chains of UR-type behavior are indeed almost inevitable with the responses reportedly conditioned at long CS-US intervals: (1) overt behavior such as eye and head orientation, or freezing and crouching, which might have been part of

the response pattern labeled "suppression of bar pressing" (Kamin, 1965); (2) heart rate (Zeaman & Smith, 1965); (3) inspiration, and (4) salivation and alimentary reflexes.

Finally, some conditioning procedures provide, if not a chain of stimuli, at least more than one change in sensory input prior to the US (e.g., onset plus termination of conditioned stimulation, and termination is a measurably effective stimulus (Kamin, 1965, p. 141)); and most procedures provide continuing conditioned stimulation which may be sampled by the S at any time, e.g., if the stimulation is illumination or simultaneous visual contrast, then eye, eyelid or head movements provide their own changes in sensory output.

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The influence of frequency of exposure on the learning of a phrase structural grammar

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Letter pairs generated by an elementary grammar were presented to college student Ss for recall. Ss were given 14 trials to learn 18 pairs, using a free recall technique. These Ss did not reach learning asymptote. Another group of Ss was given 12 pairs for 20 trials. Most Ss did not learn the pairs in these trials. The intrusions in the recall protocols suggest that the Ss did not learn the grammar from which the pairs were generated, but they learned the position of the letters in the pairs and generated sequences accordingly. Some Ss seem to have learned the presented pairs directly and these Ss tended to learn the pairs presented better. The authors concluded that mere exposure with intent to learn is not sufficient for the learning of grammatical structure.

Recent researchers (Smith, 1965; Braine, 1965; Segal & Halwes, 1965) have found that when they presented a relatively large number of verbal sequences to a group of Ss, the Ss did not learn them all. More interestingly, when Ss are given a recall or recognition task following the presentation of sequences they make errors of commission. They generate many sequences which are not presented to them. Moreover, the generated sequences are related to the presented ones in certain specifiable ways. In addition to learning some of the sequences the Ss learn rules of combination by which they generate sequences. Evidence that Ss learn rules of combination is (1) the generated sequences contain the same elements as the presented sequences; and (2) the elements in the generated sequences appear in the same position as they do in the presented sequences. These rules can be formalized by simple generative grammars (cf. Chomsky & Miller, 1963).

In the studies by Smith (1965), and Segal & Halwes (1965) the Ss were given strings of sentences to learn which were generated by grammars which contained two major classes of strings. However, when the strings generated by the Ss were analysed it was found that they could be generated by a grammar which contained a single class of strings. The present experiments were designed to investigate whether Ss can learn contingencies such that both major sentence classes are necessary to describe the S's behavior.

EXPERIMENT 1

Method

The technique in this experiment is very much like that of Segal & Halwes (1965). Ss were given a random sequence of letter pairs to learn. The pairs which they were given were generated by a grammar of the form

$S \rightarrow A+B$, $S \rightarrow B+C$. The letters A, B, and C stand for subclasses of consonants. For this particular study the A and C classes each contained 3 letters and the B class contained 4 letters. Of the 24 pairs which could be generated from this grammar 18 were presented to the 20 college students who served as Ss. The letter pairs were presented orally at a 3-sec. inter-pair interval. Ss were given 1.5 min. to write the pairs they remembered after the presentation. The sequence of presentation of the pairs followed by recall was continued for 14 trials.

Results

One analysis of the data concerns the intrusions made by the Ss in their attempt to recall the presented pairs. If they learned the pairs directly except for a few random intrusions each nonpresented pair would have equal opportunity of being "recalled." If the Ss recalled the pairs by inventing a grammar and generating the pairs then a greater percentage of the intrusions than would be expected by chance would be generated by that grammar. Three classes of intrusions were compared: (1) grammatical intrusions, those pairs generated by the grammar but not presented to the Ss; (2) semi-grammatical intrusions, those dependent upon simple position in the pair (generated by a simple grammar containing a single sentence class); (3) nongrammatical intrusions, other pairings of the presented letters. The number of intrusions in each class was divided by the total number of letter pairs in that class for the analysis. This weighting procedure corrects for the opportunities each intrusion class has of occurring.

The analysis of the intrusion data showed that the Ss invented a grammar and generated pairs. There was a large difference between the number of intrusions in each class, $F=9.91$, $df=2/38$, $p<.001$. This was entirely due to the difference between the nongrammatical intrusions and the others, $F=19.69$, $df=1/38$, $p<.001$. The difference between the two classes of grammatical intrusions was negligible, $F=0.12$, $df=1/38$. The intrusions showed no trend effects, $F=0.78$, $df=13/247$, and no significant trials by class interaction, $F=.79$, $df=26/494$. Although the Ss had 14 trials to learn 18 pairs of letters there was no sign of limiting the number of intrusions over trials. Also, the Ss simply learned a two-class grammar and did not learn to condition one class of letters to another.

It was found that after 14 trials the learning asymptote was not reached. The Ss averaged only 13.7 pairs correctly recalled on the last trial and only two recalled all 18 pairs. The Ss averaged 4.2 intrusions on the

last trial and 13 of the 20 Ss made at least one intrusion. The number of pairs recalled correctly and the number of intrusions were negatively correlated ($r = -.243$) although insignificant.

EXPERIMENT 2

Method

Because of the lack of learning restrictions either by limiting the number of intrusions over trials or by learning the specific restrictions of class membership the same general task was tried with fewer pairs and more trials. The grammatical form used in Experiment 1 was again used. However, there were only three letters in each class. From this grammar 18 pairs could be generated; of these, 12 were presented to the 20 Ss in the same manner as the first experiment. In this experiment the Ss were given one min. to write their responses and they had 20 trials.

Results

The analysis of the results for this experiment is generally similar to that of Experiment 1. The intrusions were again divided into three classes and weighted for comparison. There was a large difference between the weighted number of intrusions of the three classes, $F = 12.55$, $df = 2/38$, $p < .001$. The difference was again attributable to the difference between grammatical and nongrammatical intrusions, $F = 25.1$, $df = 1/38$, $p < .001$. There were no differences between the grammatical and semi-grammatical groups, $F = 0.002$, $df = 1/38$. Again, there were no trend or interaction effects. Most Ss again generated the pairs from a simple two-class grammar. However, the proportion of intrusions decreased from the previous experiments.

As a group, learning asymptote was still not reached, although little learning can be detected during the last 10 trials. On the twentieth trial the Ss averaged 9.7 correct pairs and 1.95 intrusions. Eight Ss recalled all presented pairs and nine made no intrusions. The number of pairs recalled correctly was inversely correlated with the number of intrusions ($r = -.569$, $p < .01$). This result is not obviously artifactual since the number correct correlated strongly ($r = +.684$) with the total number of responses emitted and there were large individual differences in this total.

Discussion

Individuals in verbal learning tend to make the assumption that given enough trials an individual will learn the task that he is given (Braine, 1965; Gough & Segal, 1965); however, this assumption is not confirmed by the results of this experiment. Although given a relatively easy task to perform and many trials in which to learn it, all Ss did not eliminate errors, either of omission or commission. Although the Ss generally continued to generate pairs according to certain rules, none of them learned the contingent relation between

the classes of letters. They still responded as though they were generating pairs from a simple one-stage two-class grammar. They learned the position of the letters in the sequence and generated sequences accordingly (cf. Braine, 1963).

The results suggest that in these particular studies there are individual differences in strategy with greater individual differences in Experiment 2. Some of the Ss attempt to generate sequences according to certain rules, whereas some of the Ss learn the pairs directly. The generative grammar, when used, was inefficient in that it generated more than twice the required number of pairs. Learning the pairs indirectly is more efficient in terms of the number of things to learn, especially for a group given a relatively small number of sequences. This efficiency is noted in the negative correlation between the number of intrusions and number of sequences emitted correctly. The Ss who adopted a rote learning strategy learned a greater number of the sequences and made fewer intrusions than Ss who generated pairs from the grammar.

The results of these experiments also suggest to the authors that Ss will not learn specific class contingencies from mere exposure to sequences generated according to those contingencies. In most studies using artificial grammars the contingency learned by Ss may be described primarily by position. Braine's (1963) theory of position of learning seems to be a good statement of what Ss do. However, an analysis of real language leads one to the conclusion that position learning is not sufficient to explain linguistic complexity. A conclusion reached is that other variables formally independent of the linguistic structure must covary with the structure in order for Ss to learn the contingencies implicit in the structure. Possible correlated variables are stress patterns and associated stimulus classes, among others.

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Note

1. Now at University of Minnesota.

Discrimination learning by retardates as a function of number of implicit response trials

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In each of 8 sessions 10 severely retarded males received 4 new 15-trial object discrimination problems. A problem began with either 0, 3, 6, or 9 initial trials during which a prompt (light cue) merely indicated the object which would subsequently be rewarded. No overt instrumental response was permitted during these prompted trials, but conventional trial-and-error procedures were followed on all remaining trials. Discriminative performance on conventional trials was directly related to the number of previously prompted trials. Confirming and extending previous research, these results forced the assumption of an implicit response which, elicited reliably by the prompt on each prompted trial, increased the probability of a subsequent correct overt response.

Two previous studies have demonstrated that an overt response-reward sequence is not a necessary condition for the solution of object discrimination problems by retardates. House (1964), merely "demonstrating" and verbalizing reward contingencies on Trial 1, found that performance of severely retarded Ss was considerably above chance on Trial 2. With similar Ss, Fletcher (1965) employed a prompt (i.e. a light indicating the correct object) and found significantly better than chance performance on the first trial following 6 prompted trials during which no overt response was permitted and rewards were neither displayed nor dispensed. This observation supported the assumption that the prompt reliably elicited an *implicit* response sequence which, in some manner, increased the probability of a subsequent correct response.

The present research was designed to confirm and extend these initial observations by relating the effect of the presumably critical implicit event to a fundamental experimental manipulation: number of trials. Specifically tested was the hypothesis that subsequent discriminative performance would be monotonically related to the number of preceding prompted trials.

Method

Ten severely retarded males (MA's 26-67 mos., median=48.5), with extensive experience in prompted discrimination learning (Fletcher, 1965; Fletcher et al, 1965) and ambiguous-cue problems², were tested daily in the apparatus shown in Fig. 1.

Multidimensional junk objects were attached to 4 x 4 in. bases which slid in channels and covered 2 foodwells 10 in. apart. A trial began as E raised a hinged door

below the one-way mirror and pushed the white acrylic plastic tray to the position shown. The S then placed his fingers on the object and pushed it back to expose the foodwell. In the trays front edge were two 1 in. jewelled amber lights which served as prompts.

Although familiar with the apparatus and procedures, Ss were first required to demonstrate retention of an appropriate response in the presence of the prompt. Two identical gray blocks were presented in four 12-trial sequences during which the prompt (light) was lighted in front of the baited block, and S was required to make 11 correct responses (to the prompted block) in any 12-trial sequence. For these and subsequent sessions, rewarded position was randomized, raisin rewards and noncorrection procedures were used, and verbal instructions were limited to essentially "find the raisin."

The test phase consisted of 8 sessions. Each session began with a 4-trial practice series during which the prompt was lighted in front of the baited one of the two gray blocks and instrumental responses to the prompted block were rewarded. Four 15-trial object discrimination problems followed and differed with respect to the number of initial "prompt only" trials. One problem per session had no prompting, hence conventional trial-and-error procedures on all 15 trials. A second problem began with 3 prompted trials and continued with 12 conventional trials. For a third problem 6 prompted trials were followed by 9 conventional trials. The fourth problem had 9 prompted trials and 6 conventional trials.

On all of these prompted trials, the prompt was lighted in front of the "correct" object, the tray was pushed forward, S was told to "look but don't touch" (all Ss obeyed instructions), and the tray was withdrawn

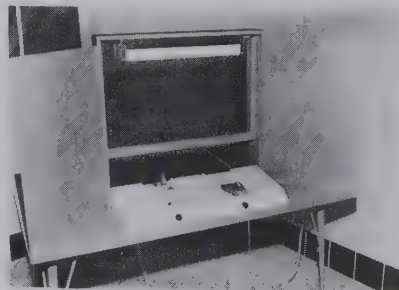


Fig. 1. Test Apparatus.

following a normal trial's duration. Conventional trials (no prompting) always followed with interruption, and responses to "correct" object were rewarded. The order of the 4 problems was randomly determined for each S independently for each session.

Results

The most direct, hence critical, measure of the effect of previous prompted trials was the number of correct responses (over all 8 problems) on the first trial in which an overt (non-prompted) response was permitted. These first-trial data (trials 1, 4, 7, and 10 following 0, 3, 6, and 9 prompted trials, respectively) are presented in Fig. 2.

The chance null hypothesis was first tested with each set of first trial data separately. Only apparently high, the mean of 60% on actual first trials was well within the acceptable range of sampling error ($t=1.394$; $df=9$; $p=.18$). Similar tests on the first-trial means following 3, 6, and 9 prompted trials yielded t values of 3.145, 6.469, and 3.473, respectively; each with $df=9$ was significant well beyond the .01 level.

The hypothesis that performance would be monotonically related to the number of prompted trials was not supported by the first-trial performance following 9 prompted trials (Fig. 2). This one data point is somewhat suspect, however, because Ss often squirmed, looked away, or seemed annoyed during the last few of the 9 prompted trials. The protracted prevention of a response may therefore have had a relatively adverse effect on the first test trial.

An indirect, but perhaps more reliable, test of the hypothesis was available in the subsequent intraproblem performance following prompted trials. Because 9 prompted trials set a maximum limit of 6 conventional test trials common to all 4 problems, intraproblem performance scores were obtained from the first 6 conventional trials following prompted trials. Indicating a slight but virtually linear relationship, these data (Fig. 2) clearly support the expected monotonic increase in subsequent discriminative performance as a function of the number of previously prompted trials. Page's Test³ ($L=273.5$; $p<.01$) confirmed the evident transitive relationship.

Discussion

These data demonstrate quite conclusively that an explicit response-reward sequence is not a necessary event for the solution of discrimination problems by even severely retarded humans. Although they were prevented from emitting instrumental responses and experiencing external rewards on prompted trials, these Ss did, when allowed, choose the correct object. Clearly, then, they were "responding" quite adequately to the situation in which a cue merely indicated the correct object. It seems reasonable to assume, there-

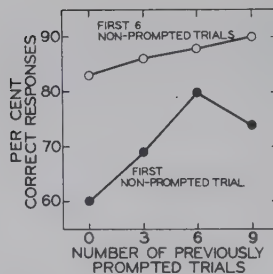


Fig. 2. Discriminative performance following prompted trials during which no instrumental response was permitted.

fore, that on each prompted trial the prompt elicited reliably and accurately an implicit response sequence which involved the prompted (or correct) object and which incrementally increased the probability of a subsequent correct discriminative response. Furthermore, the behavioral consequence of the assumed implicit response was directly related to the number of occurrences as is the probability of a correct discriminative response following conventional overt response-reward trials.

Discrimination learning theory, with its empirical foundation derived almost exclusively from conventional trial-and-error research methodology, necessarily assumes the critical event to be the effect of a reward (or nonreward) following an emitted overt instrumental response. Such a theory, in the writer's opinion, must at least struggle to account for the present results which derive from a situation manifestly involving neither an instrumental response nor a reward.

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Notes

- The author is indebted to Harvey A. Stevens and Ronald Sindberg of the Central Wisconsin Colony administration for their generous cooperation in this research and to Mrs. Mary McNamee for her assistance.
- Prepublication copies of this research are available upon request.
- This test is a particularly useful and powerful alternative to the omnibus F -test when the order of treatment effects is clearly indicated in the hypothesis. Furthermore, the test requires only ordinal level of measurement. See Page (1963).

The effect of overlearning on relearning following a confusion phase¹

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After either criterion learning or overlearning of a concept, 77 male college students, in two experiments, received a series of "confusion" trials designed to induce them to abandon their learned mode of response. Following this phase without break, S was required to relearn the concept. Overlearning facilitated relearning.

As compared with achieving a minimal criterion of errorless performance, overlearning (OL) an initial concept has been found to facilitate college students' learning of a subsequent concept, when conceptual problems are shifted without warning. Furthermore the facilitation appears independent of the number of available response categories as well as the type of shift, reversal or nonreversal (Ludvigson & Caul, 1964).

Two quite different interpretations of this facilitation might be entertained. The facilitation might be of the nonspecific, learning-set variety, involving processes which affect the learning of most, if not all, concepts. Alternatively, OL might benefit performance by affecting quite specific response tendencies.

An example of the latter type of effect is suggested by data which show that OL decreases the persistence ("R persistence") with which Ss maintain their old mode of response following the onset of the shift to the second concept (Caul & Ludvigson, 1964; Ludvigson & Caul, 1964). That is, OL reduces the number of trials S takes in making his first response different from that which was appropriate to the initial concept. While this apparent hastening of the extinction of the initial mode of response should speed S toward learning a new concept, the magnitude of the effect appears small relative to the reduction in trials to criterion resulting from OL. Thus, although contributing to the OL effect the lowered resistance to extinction revealed in decreased R persistence seems insufficient to account for the major part of the facilitation. However, OL might result in more complete extinction of the first concept in the sense that it reduces its spontaneous recovery during the trials in which S is searching for the solution to the new conceptual problem. Such an effect might be beneficial to an extent not indicated by the R persistence measure.

The present study was designed to test this possibility. Following the learning or OL of the first concept a "confusion series" was administered to induce S to change his mode of response. This was immediately followed by a shift back to the initial concept instead of to a new concept as in the previous work. If the effect of OL is to result in more complete extinction

of the initial concept in the confusion series, OL should, if anything, interfere with the relearning. Method

The materials and procedure were basically the same as those used by Ludvigson & Caul (1964). The task required S to sort 16 cards into two categories. In the first of two experiments half of the 48 male volunteers from psychology and biology classes learned the Horizontal-Vertical (HV) concept while the other half learned the Straight-Oblique (SO) concept. Within each of these groups 12 Ss were required to achieve a criterion of 10 successive correct responses (Group CL) while the remaining 12 Ss, after meeting this criterion, were given 48 additional trials before the confusion series was begun (Group OL). Similarly in the second study 15 Ss learned the reverse of the HV concept (RHV) and 14 learned the RSO, with eight of the RHV and seven of the RSO Ss given the CL treatment and the remainder given the OL treatment.

The confusion series consisted of 10 trials in which knowledge of results was given as follows. Regardless of S's response E told S he was "wrong" on the first three trials, "right" on the fourth trial, wrong on the next two, right on the seventh, and wrong on the last three. The same sequence of cards was used for all Ss in this series.

Immediately following the tenth trial of the confusion series E returned to reinforcing the concept learned prior to the confusion series. The relearning phase was continued until a criterion of 15 successive responses was reached.

Results and Discussion

The mean, median, and range of the number of trials to reach criterion (excluding criterial trials) in the initial learning and the relearning phases are presented in Table 1. In Experiment I, preliminary comparisons of the HV and SO concepts with the Mann-Whitney U test yielded values of $z=0.84$ and 0.82 ; $p>.40$ for initial and relearning phases, respectively. Pooling the data into CL and OL groups, initial learning was slightly but not significantly faster among CL Ss as compared with OL Ss according to the Mann-Whitney test, $z=0.97$; $p=.33$. Contrary to the hypothesis under test OL facilitated relearning, $z=2.103$; $p=.036$ for the comparison between CL and OL relearning scores. As may be seen in Table 1 this same conclusion was suggested by the average values of the difference scores (initial minus relearning). Wilcoxon signed-ranks analyses indicated that relearning was significantly easier in the OL but not the CL group, $t=64$; $df=22$, $p<.05$, and

Table 1. Mean, Median, and Range of Number of Trials to Criterion in Initial Learning and Relearning, and of the Difference (Initial minus Relearning) in Number of Trials.

Exp.	Group	Initial Learning		Relearning		Difference	
		Mean	Mdn.	Mean	Mdn.	Mean	Mdn.
I	CL	22.6	4.3	13.9	14.0	8.8	-1.0
		0 to 83		0 to 37		-30 to 70	
	SO	8.5	1.1	9.9	8.4	-1.5	-6.8
		0 to 54		0 to 21		-21 to 46	
	OL	30.8	11.0	7.2	4.0	23.3	7.5
		0 to 52		0 to 21		-15 to 123	
II	CL	78.5	82.0	43.1	24.0	35.4	26.5
		16 to 126		4 to 111		-37 to 122	
	RSO	21.1	20.0	25.6	15.0	-4.4	-2.0
		2 to 51		2 to 64		-44 to 18	
	OL	41.0	46.0	9.1	9.0	31.9	37.0
		9 to 72		2 to 18		-5 to 59	
	RSO	39.1	39.0	4.6	3.0	34.6	32.0
		5 to 76		0 to 16		4 to 76	

$t=129$; $df=24$, respectively. However, the Mann-Whitney test indicated that the difference between the difference scores for the CL and OL groups was significant only at the .10 level, $z=1.69$. Additional analyses, in which selected scores were omitted to ensure that the CL and OL groups were equated on the initial learning, further substantiated the conclusion that OL facilitated relearning.

The Experiment II preliminary analyses with the Mann-Whitney test revealed that the reversed concepts, RHV and RSO, differed in ease of learning in the initial phase, $U=47$; $df=14/15$; $p<.02$, but not in the relearning phase, $U=72$; $df=14/15$. The pooled CL and OL Ss did not significantly differ in the initial learning, $U=91$; $df=14/15$. Similar to Experiment I the relearning scores for the CL and OL groups were different, $U=36$;

$df=14/15$; $p<.02$, indicating that OL again facilitated relearning. Also as in Experiment I the difference between initial and relearning scores was significant for the OL group, $t=5$; $df=14$; $p<.01$, but not the CL group, $t=43$; $df=15$, while the difference between the differences was not significant, $U=67.5$; $df=14/15$.

These data lend no support to the notion that OL suppresses recovery of the initial mode of response. If OL does have such an effect, it is small relative to other more potent effects beneficial to relearning, and, in any case, cannot account for the usual facilitation of OL in reversal and nonreversal shifts.

Despite the lack of evidence for the recovery suppression hypothesis, there was some indication that, similar to the previous studies, OL Ss more quickly abandoned the original concept following the onset of the confusion series than did the CL Ss. The mean R persistence scores were 2.42 and 2.67 for the CL groups of Experiments I and II, and 2.25 and 1.21 for the OL groups of the respective experiments, yielding a $z=1.70$; $p<.05$ for the comparison across both studies with the Mann-Whitney test. The groups did not differ, however, in the number of responses in the confusion series which were incorrect with respect to the concept learned, $z=0.04$. The means were 3.46 and 2.87 for the CL groups of Experiments I and II, and 2.83 and 3.57 for the OL groups.

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Note

1. This research was supported in part by a grant from The University of Texas Southwestern Medical School. The author wishes to thank the psychology department at Arlington State College for their assistance in obtaining Ss and Erin Rayfield Brown for serving as E. A portion of this paper was presented by Mrs. Brown at the 1965 meetings of the Texas Psychological Association.

An experimental evaluation of the pseudomediation hypothesis¹

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The chaining paradigm of mediation and the corresponding paradigm of pseudomediation were compared. Significant facilitation attributable to associative chaining was obtained in the mediation paradigm whereas the pseudomediation effect previously reported by Mandler & Earhard failed to appear. The adequacy of pseudomediation as an explanation of the apparent effects of associative chaining is questioned.

Present Status of Pseudomediation

A study by Mandler & Earhard (1964) suggested that the mediation effect observed in the three-stage paradigm of associative chaining may be an artifact resulting from the difference in the amount of test-stage interference between the experimental condition (A-B, B-C, A-C) and the control condition (A-B, D-C, A-C). This interpretation is based on the assumption that the first-list associations are unlearned during the acquisition of the second list in the experimental but not in the control condition. As a consequence, the acquisition of A-C in the test stage is subject to less interference from A-B under the experimental than the control treatment. To test this hypothesis, Mandler & Earhard used a design in which the first two stages of training were the same as in the conventional paradigm but mediation was precluded in the third stage by the use of entirely new response terms, i.e., A-B, B-C, A-E for the experimental condition and A-B, D-C, A-E for the control condition. As expected, the experimental group showed negative transfer in the second stage but was superior to the control group in the third stage. (The difference between the two groups was significant for trials to the criteria of one and two perfect recitations, but not for the number of correct responses on the first six trials.) The superior performance of the experimental group in the test stage was described as "pseudomediation." It was concluded that pseudomediation was probably responsible for the apparent facilitation produced by associative chains established in the laboratory.

Further experiments and theoretical discussions stimulated by the study of Mandler & Earhard have given rise to three questions: (a) Is the pseudomediation effect reproducible? An experiment by Jenkins & Foss (1965) yielded only marginal evidence for pseudomediation, whereas Schulz, Weaver, & Ginsberg (1965) failed to replicate the effect altogether. In both these cases, however, the procedure differed from that of Mandler & Earhard. In the experiment of Jenkins & Foss a test of first-list recall was interpolated between the second and third stages; Schulz et al used different materials and multiple-choice learning in the second and third stages. A need for further replication is indicated, especially in view of the rather unusual finding of transfer effects which are maximal late rather than early in test-list learning. (b) Does the

interpolation of B-C in fact result in the unlearning of A-B, as the hypothesis of pseudomediation assumes? Since it is the backward first-list association B-A which must be assumed to be in competition with B-C, such an effect is to be expected only if unlearning is bidirectional. The available evidence on this question is equivocal. Goulet (in press) and Jenkins & Foss (1965) failed to find lower recall of A-B after interpolation of B-C than of D-C. On the other hand, Earhard & Mandler (1965) obtained the expected difference on a test of associative matching. The discrepancy can be reconciled only on the assumption that the greater loss of associations in the experimental than in the control condition is fully offset by an opposed difference in response availability. (c) If pseudomediation does occur, is the amount of facilitation large enough to provide an adequate explanation of the conventional mediation effect? This last question defines the central interpretative problem raised by the findings of Mandler & Earhard. In a direct comparison of the two paradigms Schulz, Weaver, & Ginsberg (1965) obtained a substantial amount of mediation but no pseudomediation. As already noted, however, there were important procedural differences between the latter and the original study. The use of a multiple-choice method of learning is interpreted by Earhard & Mandler (1965) as reducing task complexity and memory load so that mediational effects rather than interference have an opportunity to influence performance.

The present study addresses itself to the first and third of the above questions, i.e., the reproducibility of the pseudomediation effect and its adequacy as an explanation of the results obtained in conventional tests of mediation. A direct comparison was made between the paradigms of mediation and pseudomediation under conditions closely comparable to those of the study of Mandler & Earhard.

Method

The mediation and pseudomediation paradigms of associative chaining were used. In the mediation treatment the sequence of lists for the experimental condition (M-E) was A-B, B-C, A-C, and for the control condition (M-C) it was A-D, B-C, A-C. For the corresponding pseudomediation conditions (PM-E and PM-C) the sequences were A-B, B-E, A-C and A-D, B-E, A-C, respectively. Thus, the same test list was used for all groups, and within each paradigm the conditions of transfer were manipulated by appropriate variations in the first list. The use of a common second list within each paradigm makes it possible (a) to determine the amount of negative transfer in second-list learning, and (b) to assess the effects on test-list learning of prior familiarization with the response terms.

Lists of six paired associates were constructed from the pool of low-frequency words used by Mandler & Earhard (with substitution of *hutch* and *parle* for *prawn* and *llano*). There were three different pairings of the stimulus and response terms in each list which were used equally often. The lists were presented at a 2½-sec. rate, with a 4-sec. intertrial interval. There were four different orders of presentation. The intervals between lists were approximately one min. All lists were learned by the anticipation method to a criterion of two successive perfect recitations.

The Ss were undergraduate students at the University of California who were not necessarily naive to rote learning experiments. There were 18 Ss per group. Assignment to conditions was in blocks of four, with ones per block from each condition.

Results and Discussion

The mean numbers of trials to a criterion of one perfect recitation on the first list were 11.3, 11.7, 11.8, and 12.0 for Conditions M-E, M-C, PM-E, and

PM-C, respectively. The corresponding scores for a criterion of two perfect recitations were 15.2, 15.2, 15.3, and 15.7. For both measures $F < 1$.

There is clear evidence for negative transfer in the experimental conditions during second-list learning. The mean numbers of correct responses on the first five trials, on which all Ss were represented, were as follows: M-E—10.7, M-C—15.6, PM-E—10.7, PM-C—14.2. The difference between the experimental and control conditions is highly significant, $F=18.48$, $df=1/68$, $p < .001$. There is no interaction of paradigms with conditions, $F < 1$. With the groups listed in the same order as above, the mean numbers of trials to a criterion of one perfect recitation were 10.4, 7.0, 11.2 and 8.4, and to a criterion of two perfect recitations 14.1, 9.8, 14.0, and 10.2. For both criterion measures, the difference between the experimental and control conditions remains highly significant, $F=8.86$, $df=1/68$, ($p < .005$) and 12.32 ($p < .001$), respectively. In both cases the F for interaction is less than 1.00.

Figure 1 shows the acquisition curves for the first five trials of the third stage (with all Ss represented). Condition M-E is clearly superior to the remaining three conditions; the variations among the latter are relatively small. The total numbers of correct responses in five trials are presented in Table 1. Analysis of variance yields only one significant effect, viz., for the interaction of paradigms with conditions, $F=3.98$, $df=1/68$, $p < .05$. For the difference between Conditions M-E and M-C, $t=2.49$, $df=68$, $p < .02$. Conditions PM-E and PM-C do not differ reliably, $t=.89$, $df=68$. The small difference that is present favors Condition PM-C. As Table 1 shows, the rank order of the conditions is maintained on the criterion scores. However, analysis of variance of the criterion measures does not yield statistically reliable effects.

Reference to Fig. 1 shows that on the first trial performance in Condition M-C is slightly better than in Condition PM-C, whereas on the second trial the difference is in the opposite direction. This interaction is significant, $F=4.77$, $df=1/34$, $p < .05$. Consequently, the slope of the learning curve is somewhat steeper for PM-C than for M-C. Prior familiarization with the response terms gives an advantage to Condition M-C; on the other hand, the relationship between the second and third lists conforms to the A-B, C-B paradigm for M-C, and to the A-B, C-D paradigm for PM-C. The former may be expected to yield negative

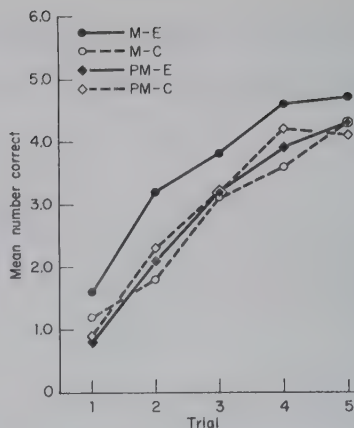


Fig. 1. Performance on the first five trials of the third stage.

associative transfer relative to the latter. The advantage of response familiarization appears to be offset by the negative transfer effects after the first trial. The equality of the two control conditions rules out the possibility that response familiarization contributes appreciably to the superiority of Condition M-E over Condition PM-E.

These results fully agree with those of Schulz et al in showing a significant amount of mediation and the absence of a pseudomediation effect. The reasons for the discrepancy between the findings of Mandler & Earhard and those of the present study are not apparent. Subtle differences in procedure or subject ability may be responsible. In any event, pseudomediation does not appear to be a strong effect which is readily reproducible. More important, however, clear evidence for mediation was obtained under conditions in which the pseudomediation effect failed to appear. The cumulative evidence available to-date makes it increasingly unlikely that chaining is an artifact attributable to pseudomediation.

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Notes

1. This research was carried out during the first author's tenure as an NIH postdoctoral fellow at the Institute of Human Learning, University of California, Berkeley.
2. Now at West Virginia University.

Table 1. Summary of Learning Measures for Third List

Cond.	Mean No. Correct	Trials to Criterion	
	Trials 1-5	One perfect	Two perfect
M-E	17.8	5.9	9.5
M-C	13.9	7.8	10.0
PM-E	14.2	9.7	12.6
PM-C	14.7	8.3	11.9

Concept identification of auditory dimensions as a function of age and sex¹

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Auditory concept identification task was presented to 200 male and female Ss between the ages of 6 and 18. Auditory dimensions of number, intensity, laterality, frequency and duration were tested for their saliency. Intensity was the most difficult dimension. Performance improved with age, although Ss in the 12-13-14 yr. old group in intensity condition made greater number of errors than both the younger and older groups. Males performed at significantly higher rate, with no difference in errors between the sex groups. Explanation of decrement in performance by the adolescent Ss was attempted.

Recent research in concept identification (CI) utilizing auditory dimensions with adult Ss indicates that there are sex differences in CI performance and that females reach solution at a significantly higher rate than males when laterality is the relevant dimension (Pishkin & Blanchard, 1964; Pishkin & Shurley, 1965). In the same experiments it was shown that the intensity dimension was more difficult to categorize than dimensions of number, laterality, frequency or duration. Since previous results are based on adult populations, it was speculated that sex differences may stem from developmental factors and are due to adult females' narcissism and their sensitivity to body stimuli (Pishkin & Shurley, 1965). Thus, it is plausible that as children grow older, males should show poorer performance on laterality as compared with females.

The present experiment focused on saliency of five different auditory dimensions in an attempt to examine the function of S's sex and age in auditory CI.

Method

The Ss were 200 male and female volunteer students between the ages of 6 and 18 years who performed on an auditory CI task to a criterion of 16 correct consecutive trials for a maximum of 192 trials. The stimuli were presented through earphones worn by S who sat in front of a panel with two response buttons with feedback light directly above each button. The Ss were told to categorize each stimulus into one of two categories by depressing a response button and that the feedback lights would indicate the correct response. The task was self spaced and the sequence of events was as follows: (1) presentation of auditory stimulus, (2) S's response, (3) feedback light on for 1 sec., (4) 3 sec. silent interval and (5) presentation of next stimulus. S's responses, feedback, response latency and type of stimulus were recorded on the Esterline Angus 20 pen operations recorder.

This was a 5 by 4 by 2 factorial design with five auditory dimensions (number, intensity, laterality, frequency, and duration); four age groups (6-7-8, 9-10-11, 12-13-14 and 15-16-17 year old Ss) and sex with equal number of male and female Ss randomly assigned to age and dimension conditions. In this paper the age groups (AG) will be referred to by the median age, i.e., AG-7, AG-10, AG-13 and AG-16.

The bileveled dimensions varied in the following manner: number (one or two tones with 2 sec. interval between them); intensity (65 or 80 db Sound Pressure Level, 250 cps); laterality (sound was presented on either left or right earphone); frequency (250 cps or 1800 cps); duration (1 sec. or 3 sec.). Only one dimension varied on any specific problem, e.g., when number was relevant, stimuli consisted of one or two sounds and the first level listed for other dimensions was consistently presented, i.e., 65 db, 250 cps, 1 sec., with the exception that sound was presented through both earphones when laterality was irrelevant. The sequence of stimuli and feedback were programmed with a Western Union punch tape-transmitter controlling the sound generator (Pishkin & Shurley, 1965).

Results and Discussion

An analysis of variance was performed on errors as the dependent variable. The main effects of Age, $F=10.95$; $df=3/160$; $p<.001$, and Dimensions, $F=5.92$; $df=4/160$; $p<.01$ were significant as indicated in Fig. 1. None of the interactions reached significance. With all the dimensions combined, there was a reduction in errors from AG-7 to AG-10, and from AG-13 to AG-16 (see Fig. 2). It is noteworthy that there was very little difference between the performances of AG-10 and AG-13. As shown in Fig. 1 this result stems

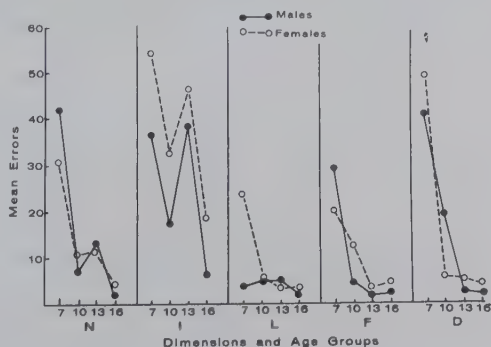


Fig. 1. Mean errors as a function of number (N), intensity (I), laterality (L), frequency (F) and duration (D) dimensions for AG-7, AG-10, AG-13 and AG-16 Ss.

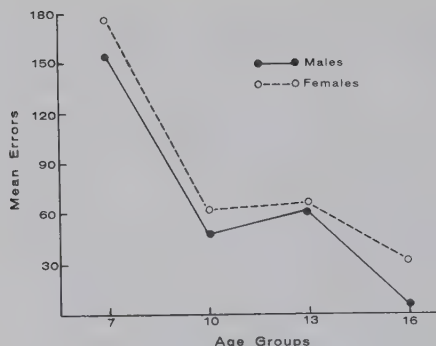


Fig. 2. Mean errors as a function of age and sex.

from greater number of errors by AG-13 than by AG-10 on number and intensity dimensions. Since it is clear that AG-13 actually produced more errors than AG-10 with sex and dimension groups combined, it is speculated that this increase in errors may be attributed to biological aspects of puberty stage, conflicts of identification, hormonal changes and generalized depression of attention span (see Fig. 2). Although it is not clear what factors play the most important role in this error increase, it is plausible that developmental stresses associated with adolescence, such as preoccupation with search for identity, restlessness and awkwardness may interfere with the trend for improvement in CI—requiring sustained attention in information processing, which was pronounced from AG-7 to AG-10. In contrast to previous findings where adult females were superior to males on laterality dimension (Pishkin & Shurley, 1965), present results indicate no difference between the sex groups. It is plausible that ability for identification of laterality deteriorates with older males.

The mean errors for dimension of intensity, duration, number, frequency and laterality were 31.85, 15.72, 15.5, 8.95, and 5.80, respectively. It is clear that intensity was the most difficult dimension, producing

significantly greater number of errors than any other dimension, as shown by Duncan's tests (lowest $df=35$; $p<.01$). There were no significant differences between errors of other dimensions (the most significant level for all pairs of Duncan's tests was $df=35$; $p<.10$). Laterality was the most salient dimension, while duration and number conditions produced essentially the same levels of performance. That the intensity dimension was most difficult confirms previous findings with adult Ss (Pishkin & Blanchard, 1964).

An additional analysis of variance was performed on the dependent variable of time to solution, consisting of total number of minutes required to complete the 192 trials or attain solution. Again, main effects of Age, $F=4.32$; $df=3/160$; $p<.025$ and Dimensions, $F=3.87$; $df=4/160$; $p<.025$ were significant. Moreover, it is noteworthy that the main effect of Sex reached significance, $F=11.94$; $df=1/160$; $p<.001$, indicating superior performance of males on this measure. The significant Age by Dimension interaction, $F=9.98$; $df=12/160$; $p<.001$, indicates there was an overall increase in time required for solution by the AG-13 Ss. A Duncan test of this interaction demonstrated that AG-13 Ss performing on intensity dimension took greater amount of time than did any other AG, including AG-7 ($df=36$; $p<.05$). Thus, the finding relative to inhibited performance of the adolescent group is supported further, demonstrating inferior response rate by the adolescent groups when compared to even the younger, AG-7 Ss.

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Notes

1. This project was supported by VA funds (8200).
2. The authors are thankful to Elizabeth A. Rasmussen and Kathryn L. West for their invaluable assistance. Audiological assistance of Howard B. Ruhm and William A. Cooper is acknowledged.

Stimulus-response durations in paired-associates learning

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This study was conducted for the purpose of determining whether stimulus-response duration, independent of distribution of practice is related to learning of verbal paired associates. Both stimulus-response duration and inter-item interval were varied. It was concluded that stimulus-response time per se does slightly affect learning, but that distribution produces a more substantial effect.

Some recent studies of the temporal aspects of paired associate learning have indicated that rate of acquisition is related to exposure time of the paired stimulus and response terms (S-R duration) (Bugelski, 1962; Nodine, 1963; Nodine, 1965). On the other hand, total learning time appears to be unaffected by variations in S-R exposure intervals. This suggests that explicit S-R duration per se may not be relevant, but rather the important factor is the differential spacing of practice which has accompanied variations in S-R presentation time. Previous studies have confounded these two variables. In other words, a short S-R duration may produce as rapid learning as a longer S-R presentation, provided Ss are given the same total time per item.

The present experiment was conducted for the purpose of determining whether explicit S-R exposure duration, independent of total list time, influences rate of PA learning. The procedures reported by Bugelski (1962) were followed.

Method

The Hunter Card Master was used to present the paired-associates materials. Briefly, this apparatus consists of a visual display unit and a separate control mechanism. Stimuli are presented automatically on cards through a 3 x 6 in. window. A twin-shutter arrangement allows independent presentation of the left and right portions of the cards. All temporal aspects of the task can be controlled automatically. The stimulus materials consisted of the following eight pairs of nonsense syllables: GEY-NUR, KAR-WEH, BIH-XIR, CEZ-MUN, FAX-SOQ, TOF-LAH, DUP-TEZ, and GAC-QET. The first syllable of each pair was the stimulus term and the second, the response term. These materials are identical to those employed by Bugelski (1962).

Sixty undergraduate students, enrolled in Introductory Psychology, were randomly and equally assigned to five subgroups. All Ss learned the eight pairs to a criterion of two successive perfect recitations. The list was presented in three different orders to avoid

Table 1.
Summary of Experimental Design and Mean Trials to Criterion

Group	S-Duration (sec.)	S-R Duration (sec.)	Inter-item Interval (sec.)	Total Item Time (sec.)	Mean Trials to Criterion
I	2	2	15	19	12.2
II	2	7	10	19	10.9
III	2	15	2	19	9.2
IV	2	2	2	6	17.6
V	2	7	2	11	11.1

serial effects. There was no intertrial rest period.

The stimulus item was exposed for 2 sec. during which time S was instructed to anticipate the response term. The S-R exposure duration and the interitem interval were different for each group. Table 1 presents the various temporal arrangements. Groups III, IV, and V represent essentially a replication of Bugelski's conditions.

Results and Discussion

The criterion measure consisted of the number of trials required to learn all eight pairs to two successive anticipations. Means are presented in Table 1. The standard deviations ranged from 4.1 to 6.1.

Analysis of variance of these data yielded $F=5.4$ ($p<.05$). An inspection of Table 1 reveals that a short S-R duration is not associated with particularly poor performance, provided total item time is beyond some minimal value. This effect is most clearly seen in comparison of Groups I, III, and IV. Rehearsing appears to occur about equally well whether or not the pair is physically present. It can be concluded that total item time is more crucial, within the limits explored here, than explicit S-R presentation per se. This statement, however, must be qualified to the extent that there was a tendency for item duration, independent of total item time, to be related to performance. Group III tended to perform slightly better than Group I ($p<.10$). The requirements placed on a short-term memory trace would appear to be greater in the situation where the item exposure time is short.

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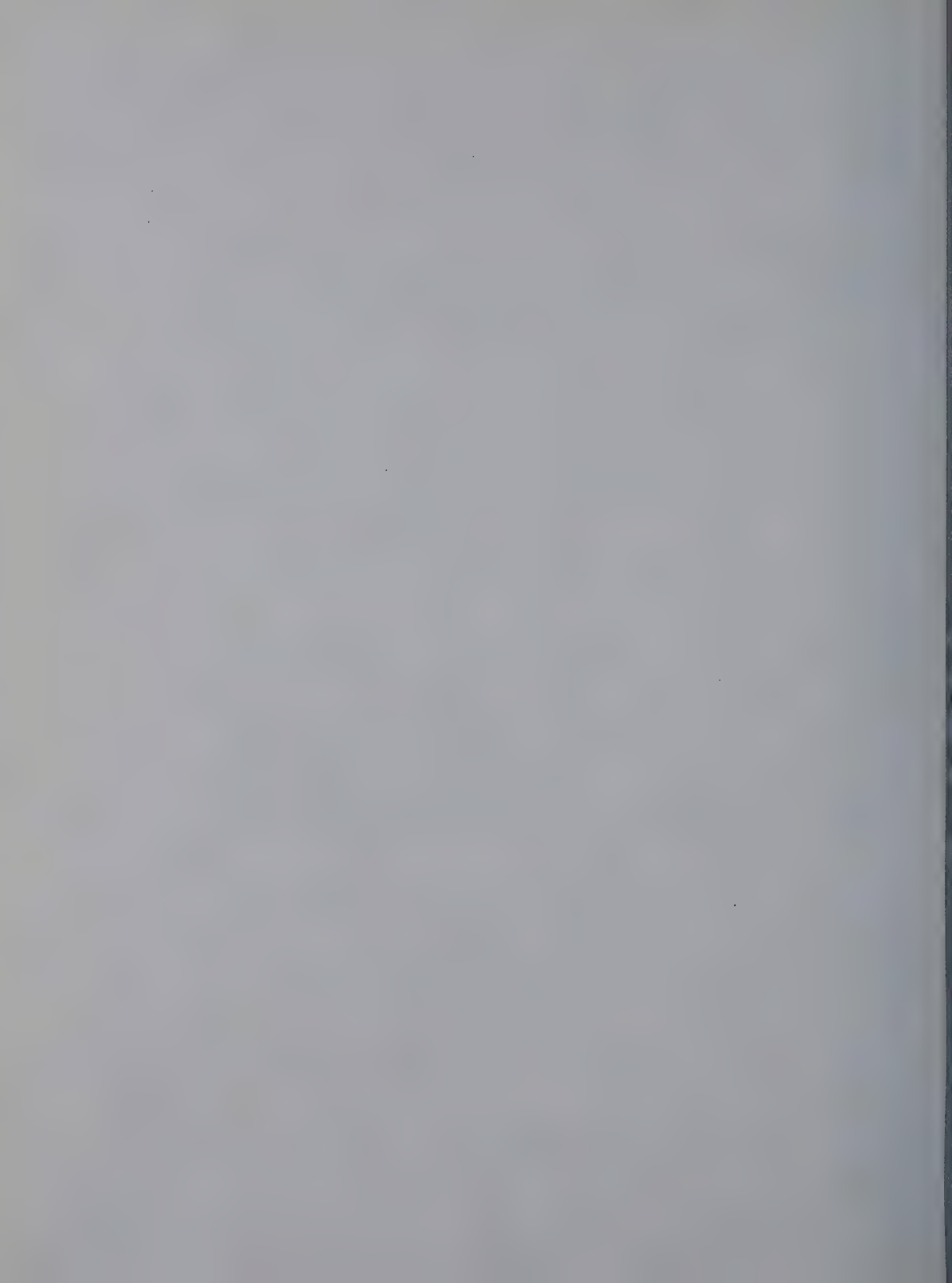
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Memory consolidation: Probit analysis of retrograde-amnesia data¹

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Probit analysis of retrograde-amnesia data reveals a normal distribution of memory indicant to the logarithm of the consolidation interval. The probit regression lines of three comparable experiments in rats have similar slopes. Conflicts in published consolidation times may arise from differences in learning strengths and artifacts of data handling. Consolidation half-time is proposed to replace consolidation time.

A clue to memory fixation may be found in the consolidation hypothesis, which leads to the inference that the time-course of retrograde amnesia (RA) reflects the kinetics of the rate-determining step of the fixation process. The hypothesis is embarrassed by conflicting values for consolidation time (CT), that contribute to conflicting interpretations of RA experiments (Lewis & Maher, 1965). Probit analysis² of published data suggests an approach to reducing the conflict.

Method

Published RA experiments with rats (Table 1) were selected by four criteria: one-trial learning; interruption by electroconvulsive shock (ECS); at least four trial-to-ECS intervals; and at least 10 Ss per group. The data of Experiment 2 permit a good test of probit analysis because they are based upon: a large, uniform group size ($N=30$); a large number of trial-to-ECS intervals (8); a nearly-geometric progression of the intervals; a high control response (100%); and a wide range of experimental responses (10 to 90%).

The "indicant" of memory is avoidance of foot-shock, quantified as percentage of the control avoidance. The "consolidation interval" is considered to start 0.5 sec. after the onset of foot-shock, because of the evidence that 0.5 sec. establishes avoidance (Chorover & Schiller, 1965). The conventional practice is to measure trial-to-ECS intervals from the termination of

foot-shock, on the assumption that memory consolidation starts only then. The resulting error (0.5 to 3.5 sec. in Experiments 1 to 4) is negligible for trial-to-ECS intervals of 75 sec. or more, but is significant for intervals of 0.1 to 10 sec.

The data are plotted on linear coordinates in Fig. 1A and 2A, and on the probit scale in Fig. 1B and 2B, with regression lines fitted by the method of weighted least-squares.³

Results

The asymptotic rise of the indicant in the linear plots precludes determination of a precise end-point. As a result, published values for RA duration are indefinite and do not lend themselves to comparison of different experiments. The consolidation half-time (CT_{50}), the interval at which the experimental Ss emit one-half of the control response, is a more reliable point statistically. It is proposed that the CT_{50} replace the indefinite "consolidation time." The probit transformation permits precise determination of the CT_{50} and its confidence limits (Table 1).

The four regression lines (Fig. 2B) do not deviate significantly ($p=0.05$) from parallelism with one another, by the Litchfield & Wilcoxon test. The data of Experiment 4, however, are significantly heterogeneous by the chi-square test and have little weight. The constants of the expression for the regression lines, $y = a + \beta \log t$, are given in Table 1.

Discussion

The similar values of the slope constant β suggest that the rise of the indicant reflects a similar consolidation process in Experiments 1 to 3 and that the

Table 1.* Consolidation half-times (CT_{50}), a values, and slope constants (β)

Experiment	CT_{50} (sec.)	a	β
1. Chorover & Schiller	9.1 (7.0 to 11.7)**	2.5	2.6
2. Quartermain***	12.3 (9.0 to 16.8)	3.0	1.9
3. King	1120. (500. to 2530.)	0.6	1.4
4. Weissman****	190. (43. to 860.)	--	--

* Based upon corrected trial-to-ECS intervals.

** The values in parentheses are the 19/20 confidence limits. The 19/20 confidence limits of β for Exp. 1, 2, and 3, are (2.1 to 3.7), (1.4 to 2.8), and (0.9 to 3.9), respectively.

*** The 0.1 sec. datum is suppressed.

**** The data are significantly heterogeneous, therefore the derived values ($a = 3.0$; $\beta = 0.9$) have little meaning.

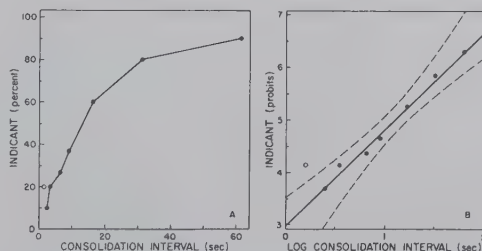


Fig. 1. Time-course of Exp. 2, plotted on linear coordinates (A) and on the probit scale (B). The open circle indicates a datum at 0.1 sec., suppressed because of uncertainty in the duration of relay-and-timer-lag. The dashed lines show the 19/20 confidence limits of the regression line.

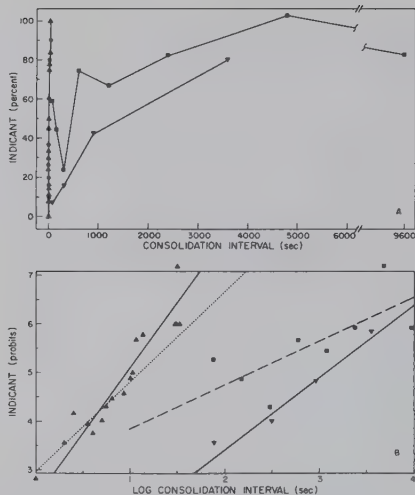


Fig. 2. Time-course of RA experiments, plotted on linear coordinates (A) and on the log-probit scale (B). Exp. 1 - upright triangles; Exp. 2 - circles (A) and dotted line (B); Exp. 3 - inverted triangles; Exp. 4 - squares. (When plotted on an expanded time abscissa, Exp. 1 also shows an asymptotic rise.)

conflicts in published values of CT may arise largely from differences in the values of a . The latter is the y-intercept of the regression line at $\log t=0$,

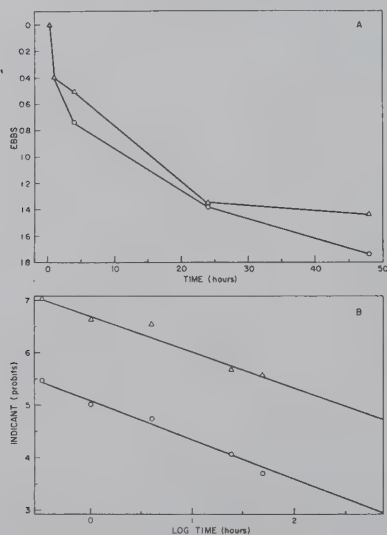


Fig. 3. Time-course of forgetting, from data of Luh (1922), as given by Bahrick (1965), plotted in ebb units and linear time (A) and in probits and log time (B). Recognition scores are represented by triangles; anticipation scores by circles.

i.e., a is the indicant, in probits, when $t=1$ sec. Determination of a values may provide a means for quantitating learning strength; for consistent results in RA experiments, supra-maximal strengths should be employed.

Probit analysis is facilitated by using the graphical method of Litchfield & Wilcoxon (1949), with two constraints: equal numbers of Ss per group (preferably 30 or more) and a balanced geometrical progression of intervals (e.g., $t/4$, $t/2$, t , $2t$, and $4t$, where $t=CT_{50}$, estimated from pilot experiments).

An application of probit analysis to memory decay is shown in Fig. 3B for comparison with the ebb transformation (Fig. 3A) of Bahrick (1965). It may be inferred that the decrease in the indicant, in probits, is normally distributed with the logarithm of time. The rate of decay, in these terms, is the same for recognition or anticipation performance ($\beta=-0.7$) but the retention half-time (RT_{50}) is 300 hr. for recognition performance and 1.3 hr. for anticipation performance.

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Notes

1. Supported by USPHS Fellowship 1-F3-MH-25,443-01, NIMH and the Veterans Administration, Sepulveda, California.
2. Probits are "probability units," equal to the normal equivalent deviate plus the arbitrary value 5.00, added to avoid negative numbers. The rationale, application, and limitations of probits are discussed by Finney (1952, 1964), Litchfield & Wilcoxon (1949), and Riggs (1963). Bahrick (1965) analyzed the variables which affect forgetting and the assumptions which underlie the use of variance units for the indicant of memory, and applied to memory-decay data a Z-transformation that is essentially the probit transformation ($Z\text{-score} + 5.00 = \text{probits}$). The same assumptions apply to the use of probits.
3. I thank R. N. Lane for programming and computing the probit transformation.

Dissociation of conditioned emotional and avoidance responses due to ECS: A cautionary note¹

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Because of the measures of conditioned emotional response (CER) used by Gerbrandt (1965) and certain other methodological difficulties, his results are not considered crucial to the hypothesis that the impairment by ECS of previously learned responses may be due to some competing response conditioned to cues associated with the ECS coma.

As there are several errors in Gerbrandt's recent paper in this journal (1965), it is necessary for the sake of the reader that they be corrected. Some are simply errors in reporting; others are more germane to the issue of his study.

Maher & McIntire (1960)—McIntire was misspelled—did find that lesions of the frontal area affected the locomotor component of the CER, leaving the defecation component unchanged. Frontal lesions abolished the tense motor "freezing" response—the animals became very active and mobile after the lesions. Gerbrandt apparently was using the term CER in a few places to mean simply defecation and urination in the face of threat. This is, of course, not the generally accepted meaning of the term; rather the freezing response is the component of the fear response that has usually been referred to as the CER and the one we had in mind in proposing our hypothesis. On the other hand, he goes on to state that the CER has been reported as having a suppressant effect on operant behavior—a difficult situation to envisage if the CER is defined purely in excretory terms. Of course, the suppression of ongoing motor responses is the most customary operational definition of the CER, and it is this suppression of locomotion that did disappear in the Maher and McIntire study. In brief, the Maher and McIntire study was reported inaccurately, and a new definition of CER was made without being clear and consistent about it.

In the light of this it is difficult to know how to evaluate the comment about the avoidance deficit found in frontal animals by Thompson (1964), a difficulty that is compounded by the lack of any citation of this study in the *References*.²

However, Gerbrandt's ambiguity about the meaning of CER seems unimportant to his own study. In his investigation it is clear that he refers only to defecation and urination. He feels that the dissociation reported between this pattern of response and avoidance responding is "crucial in determining the validity of the recent hypothesis of ECS effects advanced by Lewis & Maher (1965)." (The citation of this hypothesis was incomplete

and erroneously attributed to the *Psychological Bulletin*. The relevant article appeared in the *Psychological Review* and is cited correctly at the end of this paper.) Gerbrandt opposes our hypothesis of conditioned inhibition to the hypothesis that ECS produces retrograde amnesia. We do not, of course, dispute that ECS produces impairment in the performance of previously learned responses. What is at issue is whether this impairment is to be ascribed to engram destruction, or whether it is due to the interference of some competing response (of which conditioned inhibition is just one possibility).

Nor is there any intention to deny that memory has a physical basis in neural tissue and is therefore, presumably, frangible under some circumstances. What we are interested in is explaining the large bulk of data on behavioral deficit following ECS in the many studies in which engram destruction was not a plausible alternative, e. g., those involving proactive effects, multiple convulsions, etc.

Our inhibition hypothesis suggests that the cues immediately present and specifically associated with the onset of ECS-produced coma might become conditioned stimuli for sub-comatose behavior, i. e., for behavior associated with low levels of arousal. In discussing this possibility we noted that Williams (1961) had pointed out an interesting paradox of electroconvulsive shock: "She noted that following ECS, the treated animals when in their home cages huddled in a ball in the rear corners of the cages or crouched on the food containers. They were hyperirritable when handled and squealed, leaped or froze when E attempted to lift them"! This behavior was in marked contrast to their response when faced with the experimental apparatus in which a CER had been established earlier. "In this experiment, the ECS animals behaved as if the grid were not emotion arousing" (Lewis & Maher, 1965, p. 235). This is an excellent description of the state of affairs we have in mind. Others have made similar reports of lowered emotionality following ECS (e. g., Page, 1941).

Gerbrandt appears to have measured (i. e., assigned points for) defecation and urination while the rat was "being carried from its home cage, and being introduced into the avoidance apparatus with ear-clips attached." On the other hand he has measured "avoidance" in terms of the animal's behavior while on the safe platform. As he has failed to indicate how many of the emotional responses (defecation and urination) were produced during handling en route from cage to appara-

tus and before the moment of being placed on the platform, it is not possible to know what his data represent at all! The key stimulus situation is obviously the one that exists for the animal on the platform, not the complex of stimuli associated with being handled, lifted out of a cage, etc. In most laboratories this kind of stimulation has been paired with many other random events and would be difficult to establish as a CS for a response that was to come in an apparatus some time later. If this kind of handling en route to an experimental apparatus were likely to become a CS for the specific responses that are to be elicited in the apparatus, the conduct of conditioning experiments would be very difficult indeed!

His data regarding the avoidance responses are, on the contrary, pertinent to our hypothesis, dealing as they do with behavior that is under the stimulus control of features of the experimental apparatus. Here we see that the effects of ECS appear to include an absence of the tense crouching that is produced by footshock. Just as we predict, fear motivated crouching has not developed although we cannot tell whether the ECS rats are less aroused than control rats for there are no data to provide us with a base rate for stepping off or staying

Reply to Maher and Lewis by Lauren K. Gerbrandt

In publishing my paper in this journal, I intended to show that the Lewis and Maher hypothesis (1965) is based on the assumption that changes in the CER are a necessary condition for changes in the occurrence of avoidance, and that evidence to date does not bear out such an assumption. I pointed out that although some studies have shown correlations between freezing, response suppression, urination-defecation and other indicants of the CER and avoidance performance, Kamin, Brimer, & Black (1963) have clearly shown that suppression effects of the CER are routinely *lessened* while animals were becoming maximal in avoidance performance, whereas declining avoidance performance during extinction was not accompanied by decreases in suppression effects. Since changes in the CER do not seem to be a necessary condition for changes in the occurrence of avoidance, their presence or lack as affected by ECS was not deemed theoretically relevant to changes in avoidance. I simply stressed the possibility that my data were just a small part of the vast literature accruing (Thompson, Lesse, & Rich, 1963; Kamin, Brimer, & Black, 1963; Mikulus & Isaacson, 1965) which points to the same conclusion. Since Thompson, Lesse, & Rich (1963) found conditioned emotional responses such as squealing and abrupt changes in respiratory rate independent of the conventional freezing indicator used by Maher and Lewis, it was tentatively concluded that a necessary relation also does not exist between activity and the CER and the other CER effects. Since I had found a linear relationship between urination-defecation and avoidance

on the platform by unshocked, unpunished animals.

Under the circumstances, therefore, we must point out that the hypothesis that we have advanced is not tested by this study, the results of which are hardly "crucial" in determining its fate. Coming as they do, from an ECS study that uses multiple treatments, they are, of course, irrelevant to consolidation theory also.

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Notes

1. This paper was prepared with the support of Grant No. MH 07129 of the National Institutes of Health.
2. Because of this, we cannot cite it in the references either.

performance in the footshock group of a previously published study (Gerbrandt & Thomson, 1964) it was decided to replicate this portion of the study in comparison with ECS punishment. The group of animals given ECS as punishment again showed very little avoidance of ECS, although their emotionality was easily chained back by conditioning (even after a single ECS) to the cues of picking up the animal from his home cage for daily trials. Contrary to the subjective evidence of Williams (1961), while in the apparatus these subjects would often squeal and tremor. The apparatus was particularly bothersome to clean after a day's "run" with these animals. It is surprising, even though theoretically irrelevant, that Maher and Lewis question the emotionality of these animals. Because of limitations in article length in this journal, it was withheld that 75% of these rats developed severe stomach ulceration (4 or more lesions larger than 2 mm) as a result of ECS administration. Perhaps Maher & Lewis should clarify these interesting ramifications of "relaxation"! The ad hoc referral to "absence of tense crouching" in the performance of these animals might better be termed "an absence in memory of which response was punished." Deficits in recall due to ECS have been reported as well in humans (Williams, 1950). Humans have also shown evidence of *increases* in emotionality due to threat of impending ECS treatments (Kast & Zweibel, 1954). These CER effects were greatest when patients were in the place of ECS delivery.

If we are to consider viable the Lewis and Maher

Continued on page 198.

Lack of facilitation of learning by strychnine sulphate¹

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A study designed to test the hypothesis that strychnine sulphate facilitates learning showed that strychnine has no effect on the learning, performance, or reversal of a simple maze habit. Possible explanations of the discrepancy between these results and those of other experimenters emphasize the role of strain differences and task difficulty.

A number of recent studies have shown that pre- or post-trial injections of strychnine sulphate and other drugs have facilitatory effects on learning in the rat (for a review see McGaugh & Petrinovich, 1965). However, a few experimenters have found no facilitation of learning attributable to strychnine. For example, the findings of Keleman & Bovet (1961), although they are usually interpreted as favorable to the strychnine-facilitation hypothesis, can be seen as pointing to quite another conclusion. They report that strychnine does not speed the learning of an avoidance response to shock, but only quickens the generalization of the learned response to a heat stimulus. Furthermore, Prien, Wayner, & Kahan (1963) have attacked what they feel are certain methodological flaws (e.g., data analysis and control for sex differences) in previous work. Improving the procedure, they found no differences in maze errors between several experimental (strychnine and picrotoxin) and control (saline) groups. The basis of the discrepant findings is not known, owing mainly to the paucity of published negative results. Further reports of positive and negative experimental results should elucidate the conditions under which the facilitatory effect may or may not be obtained. Thus the present study was designed to determine the effects of strychnine on the learning, performance, and reversal of a simple maze habit by hooded rats.

Method

The Ss were 18 experimentally naive male hooded rats of the Royal Victoria Hospital strain, 200-250 gm., obtained from Quebec Breeding Farm. They were housed in pairs with ad libitum water. A schedule of 1 hr. in 24 hrs. feeding of Purina Lab Chow pellets was begun 3 weeks prior to training and continued throughout the experiment. Ss were tested when 8-10 hr. food deprived.

The apparatus consisted of a T-maze, constructed of 1/4 in. unpainted plywood, with a grid floor and wire mesh cover. The interior dimensions were: height, 5-1/4 in.; width, 4 in.; stem length, 12 in.; length of each arm, 11 in.; length of start and goal boxes, 7 in. Metal food cups were mounted in the middle of the end wall of each goal box, 1-1/2 in. above the grid. Guillotine doors controlled access to the start

Table 1. Mean number of correct choices out of 10 during learning

Day	Experimental Group	
	S-S & S-C	C-S
1	6.91	7.17
2	8.25	8.33
3	9.46	9.17
4	9.00	9.33
5	9.50	10.00

and goal boxes. A 0.1 sec. elapsed time meter was automatically activated when the start door was raised and was stopped by E when S entered a goal box. The maze was lighted by an overhead fluorescent fixture and no attempt was made to restrict extra-maze cues.

On the basis on mean running times during 3 pre-training trials in which both goals were positive, Ss were assigned to one of 3 equal groups, such that the mean running times for all groups were approximately the same. The groups, named according to the treatments they received during (1) learning and (2) performance, were strychnine-strychnine (S-S), control-strychnine (C-S), and strychnine-control (S-C).

A position habit to the side that was non-preferred during pretraining was established using the non-correction method. Ss were given 10 massed trials per day (intertrial interval approximately 5 sec.) until the criterion of 9 consecutive correct choices out of 10 was met. The reward for each correct choice was 3 40-mg pellets. Ss were weighed and injected intraperitoneally with 0.30 mg/kg strychnine sulphate solution or 1.0 cc/kg physiological saline 15 min. before the first trial of each day. Errors and running times were recorded.

Ten days after the learning criterion had been met each S was given 10 performance trials on one day under the performance drug condition assigned to its group. The testing procedure was identical to that used during learning trials.

Since reversal learning should be most difficult for Ss which had best learned the original task, 3 days after the performance day the correct side was changed. Ss were trained in one day, using the same procedure, until 9 consecutive correct choices were made. No injections were given.

Results

The data of the 2 groups receiving strychnine during learning, S-S and S-C, were combined as there were no differences in the treatment given to these groups during this phase. The mean number of correct choices made by the combined strychnine group as compared to the control group on each day is shown in Table 1.

Table 2. Performance and Reversal Results

Performance	Experimental Group		
	S-S	C-S	S-C
Mean number correct choices out of 10	9.5	9.5	10.0
Mean running time in sec.	2.84	2.50	2.60
Reversal			
Mean trials to criterion	32.0	25.7	22.8
Mean total errors	13.3	11.5	10.2
Mean running time in sec.	3.77	4.17	3.63

On no day was there a significant difference between the groups. Furthermore, there were no significant differences in trials to criterion or in mean running time between the groups. There were no significant differences during the performance trials among the groups in mean number of correct choices or running speed, as shown in Table 2. Table 2 also shows that Group S-S required the greatest number of trials to criterion during reversal, and that Group S-C was the quickest to learn the new task. Thus of the 2 groups receiving strychnine during learning, one reversed faster than the control group and the other slower, and between the 2 strychnine groups themselves there was a significant difference ($t=2.38$, $p<.05$). There were no significant differences among the groups in mean total errors or running time.

Discussion

The finding that strychnine does not change the efficiency of performance of an established habit is in agreement with McGaugh, Thomson, Westbrook, & Hudspeth (1962). The failure to find any effects of strychnine on rate of original learning or reversal learning, however, is in direct contradiction to the results of McGaugh and his collaborators. The significant difference between the 2 strychnine groups in reaching the reversal criterion is most likely due to some factor other than strychnine, since mean total errors was not affected. Since this study is one of a very few reporting lack of facilitation, it would be useful to examine the unique conditions under which facilitation has been demonstrated.

Positive results have been obtained primarily in multiple-unit mazes or a discrimination apparatus, whereas the present experiment was conducted using a position habit in a one-unit T-maze. The complexity of the task might be held responsible for the discrepancy in results, as it might be argued that the effect can be observed only in a complex learning situation. This argument is vitiated, however, by the

fact that Prien et al used a complex 32-unit maze and found no differences in rate of learning.

Available evidence indicates that the most important factor is the strain of rats employed. Facilitation of learning has been obtained primarily with strains which have been selectively bred for some characteristic, such as intelligence (Tryon S₁ and S₃) or low cortical acetylcholinesterase activity (RDL and RCL). This suggests that some unique characteristic of the rats, developed through intensive inbreeding, may be the crucial factor. Sensitivity to strychnine differs from strain to strain as well (McGaugh & Petrinovich, 1965), and although the dosage level in the present experiment was identical to that used in many other studies in which facilitation has been observed, it may have been too low to produce the effect.

It has also been noted that the Tryon dull strain is helped by the administration of facilitatory drugs much more than the bright strain, suggesting some sort of ceiling effect (McGaugh, Westbrook, & Burt, 1961). Thus it is probable that the present failure to observe strychnine-induced facilitation was caused by a combination of task difficulty and strain differences. Apparently the rats in this investigation were too bright or too insensitive to strychnine to be significantly aided by strychnine in learning such an easy task. Many more studies are necessary to adequately define the effects of these and other variables in the production of facilitation.

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Note

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Startle decrement and secondary reinforcement stimulation¹

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The following study was designed to test the hypothesis that the decrement in startle response to a percussive auditory stimulus, measured in the presence of an extraneous stimulus, is greater if the extraneous stimulus had been previously associated with receipt of food (i.e., is a secondary reinforcer). Two groups of food-deprived rats were given equal experience with a visual-auditory stimulus in a stabilimeter box, but for Group E, this stimulus was paired with food, while for Group C, it was not. All Ss received the startle stimulus, a loud "pop," for 8 trials a day over 3 test days, with the extraneous stimulus present on half the trials. Startle decrement in the presence of the extraneous stimulus was significantly greater for Group E than for Group C on Test Day 1 ($p < .02$) and over Test Days 1-3 ($p < .025$), confirming the hypothesis.

Armus et al (1964) presented evidence that the startle reaction to a percussive, auditory stimulus was reduced in the presence of an intermittent visual-auditory secondary reinforcer. Previously Trapold (1962) failed to find this effect. However, Trapold employed startle stimulus adaptation trials, and also presented the startle stimulus during the secondary reinforcement training phase while in the Armus et al study, there was no opportunity for adaptation to the startle stimulus to occur before the extinction (test) sessions. (It should be noted that Trapold organized his study around the concept of incentive motivation, rather than secondary reinforcement.)

In 1963, Hoffman and Fleshler reported that intermittent white noise, per se, lowered the startle magnitude of rats to an auditory startle stimulus while steady white noise raised it. No differential effects were found for intermittent, steady, and absent light, as opposed to white noise. Although the startle stimulus, extraneous stimulus, and response measure were different from that used by Armus et al, it was decided to determine whether the reported startle suppression associated with the presence of the secondary reinforcer resulted from the secondary reinforcing qualities of the extraneous stimulus, or from its purely stimulus qualities.

METHOD

Subjects and Apparatus

Ss were 38 naive, male, albino rats, 102-111 days old at the beginning of training. The apparatus, previously described (Armus et al, 1964), was a small plywood box fitted with a food cup and having a 6 w clear lamp mounted on its transparent lid. The "firing" of a Super Nu-Matic paper punching pistol provided the startle stimulus, and S's startle response was

transmitted to a recording pen by means of a thread and pulley system. The startle response was recorded in mm. of pen deflection with no correction for arc distortion. The secondary reinforcement stimulus consisted of the repeated flashing of the aforementioned lamp and the associated clicking of a relay. The study was carried out in a sound shielded, dimly illuminated room of high accoustical reflectivity.

Procedure

Ss were housed in individual cages with water always available. Eleven to 12 days before the beginning of pre-training, Ss were put on a feeding schedule of 1 hr. access to dry Purina Laboratory Chow checkers every 24 hr., arranged so that Ss were approximately 20 to 23 hr. deprived when run. Ss received 2 days of pretraining, 16 days of training, and 3 days of testing.

Ss were divided into two groups, E ($N=20$) and C ($N=18$). For Group E on Pretraining Day 1, the food cup in the stabilimeter box was baited with 15 45-mg. food pellets (P. J. Noyes Co.), and, when these had been consumed by the rat, 15 more were delivered manually, one at a time. Pretraining Day 2 was similar, except that the food cup was baited with only 1 pellet and a total of 49 pellets was delivered manually at 15-sec. intervals. On each of the 16 training days, each S of Group E received 20 food pellets in the stabilimeter box. The intertrial intervals (ITIs) were scheduled in 4 blocks of either 20, 40, 60, or 80 sec. each, with 5 pellets being delivered in each ITI block. The order of ITI blocks was arranged in a Latin square over 4 training days, this Latin square being repeated 3 times over the 16 training days. At the beginning of each trial, the secondary reinforcement stimulus (flashing light and relay clicking) came on for 10 sec.; after 6 sec. of this stimulus, a food pellet was manually delivered to S. At the end of the 10-sec. period, the timing mechanism was automatically reset, and the next interval was begun. The procedure was identical for Group C, except that no food was delivered in the stabilimeter box, either during training or pre-training. Five min. before the daily feeding period, Ss of this group received, in their home cages, the same number of 45 mg. food pellets as Ss of Group E had received in the stabilimeter box.

For Group E, testing differed from training in that a food pellet was no longer delivered on each trial, the startle stimulus (shot) being presented in its place. There were 3 test days with 8 test trials per day, 4 with the startle stimulus being presented at the usual time of food pellet delivery and the secondary

Table 1. Mean Startle Deflection in mm. for Experimental and Control Groups, Stimulus-Present and Stimulus-Absent Conditions

Group	Condition	Day 1		Day 2		Test Day		Day 3		Days 1-3	
		Mean Startle	Difference	Mean Startle	Difference	Mean Startle	Difference	Mean Startle	Difference	Mean Startle	Difference
E:	S ⁺ absent	34.11		31.69		26.93		30.99			
	S ⁺ present	22.14	11.97	21.10	10.59	16.58	10.35	19.92	11.07		
C:	S absent	27.59		30.88		27.00		28.48			
	S present	25.78	1.81	23.74	7.14	20.73	6.27	23.21	5.27		

reinforcement stimulus present, and 4 with the startle stimulus presented in the absence of the secondary reinforcer. The test trials were arranged in ABBABAAB sequence, "A" signifying a secondary reinforcement trial for approximately half the rats and a non-secondary reinforcement trial for the other. The precedure, including the temporal sequences, was identical for Group C. Of course, the light-sound stimulus for this group presumably did not function as a secondary reinforcer, as there had been no previous pairing with delivery of food. The ITI during testing was 50 sec., the mean of the 4 intertrial intervals used during training. The sound of the paper drive mechanism was present throughout all phases of the experiment.

RESULTS

It was predicted that the suppression of startle in the presence of the light-sound stimulus would be greater for Group E, for which this stimulus was presumably a secondary reinforcer, than for Group C, for which it was not. The results, presented in Table 1, show that this was the case.

For each test day and for all 3 test days combined, each S was assigned a score which was the difference between the mean startle response in the absence of the light-sound stimulus and the mean startle response in the presence of this stimulus. U-test analyses of these difference scores revealed a significant effect on Test Day 1, $U(18,20)=101$, $p<.02$ and over Test Days 1-3, $U(18,20)=111$, $p<.025$, supporting the hypothesis.

DISCUSSION

The data here reported support the view that the decrement in startle observed in the presence of an extraneous visual-auditory stimulus is greater if that stimulus had been previously associated with the receipt of food (was presumably a secondary reinforcer) than if it had not been so associated with food. Unlike the study of Armus et al (1964), the effect was greater on the first day of testing than on later testing days.

The studies of Brown, Kalish, & Farber (1951) and Meryman (1952) show that rats startle more when fearful than when less fearful and when hungry than when less hungry, i.e., when under relatively high as opposed to relatively low drive. Reasoning from these

studies, the present results can be interpreted as indicating that the presence of a secondary reinforcement stimulus lowers the general drive level. If so, this mechanism may be basic to the reinforcing properties of conditioned reinforcers in general.

Granted that the depression of startle in the presence of the light-sound stimulus was greater when this stimulus had been previously associated with the receipt of food, one can still maintain that this greater decrement resulted from postural adjustments or other anticipatory responses that the animals assumed when the stimulus was presented, rather than from secondary reinforcing properties of the stimulus. However, the construct of secondary reinforcement is not necessarily limited to central nervous system activity. It may well be that the secondary reinforcing properties of a stimulus are dependent, at least in part, on feedback from such postural adjustments, fractional anticipatory responses, and other peripheral reactions to the stimulus. A similar analysis can be applied to the view that the obtained difference, although resulting from the secondary reinforcement properties of the stimulus, involved postural adjustments, etc., rather than a reduction in general drive. Peripheral responses may be heavily involved in what is termed "drive." The generality of the findings would, of course, be extended if responses other than whole body startle were to show similar effects.

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Note

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Differences in the effectiveness of optic uncrossed fiber systems in albino and hooded rats¹

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Pattern discrimination performances were evaluated in albino and hooded rats surgically limited to uncrossed optic fiber systems. These pathways proved far less effective in albino than in hooded rats, thus providing a partial explanation of the marked differences in interocular transfer exhibited by the two strains.

Hooded rats exhibit high level interocular transfer of either black-white or pattern discriminations (Sheridan, 1965), and in this regard they resemble more advanced mammals such as cats (Myers, 1962), monkeys (Downer, 1962) and chimpanzees (Black & Myers, 1965). Albino rats, in sharp contrast to hooded rats trained under identical circumstances, display only very low level interocular transfer (Sheridan, 1965; Sheridan & ShROUT, 1965), their performances being similar to those of submammalian forms such as pigeons (Levine, 1945) and goldfish (McCleary, 1960). Sheridan (1965) suggested that these strain differences in interocular transfer might be due to a further reduction in albino rats of the sparse uncrossed fiber bundles which characterize rodents in general, and this suggestion has since been confirmed at the anatomical level (Lund, 1965). But the quantity of fibers necessary to mediate visual pattern discriminations is very small (Lashley, 1939), and it, therefore, remains to be demonstrated that the structural differences in uncrossed fiber density have a parallel in the relative ability of albino and hooded rats to acquire visual discrimination habits via the uncrossed fiber bundles. It was to this end that the present experiment was undertaken.

METHOD

Subjects

The Ss were 11 albino and 9 hooded rats which had survived stereotaxic sectioning of the corpus callosum and severance of some part of the optic pathway.

Apparatus

The apparatus, which has been described in detail elsewhere (e.g., Sheridan, 1965), utilized escape from shock as reinforcement, and consisted of a start box, runway, choice point with two alternative entryways, and a goalbox.

Procedure

Surgery: A modification of a previously described (Sheridan, 1965) surgical technique was used in making the lesions. Lesions (e.g. optic tract section, mid-line section of chiasm) were made in the area of the optic chiasm by stereotaxically lowering a sharp needle in a dorso-ventral direction until it reached the floor of the skull. In the same operation, the

corpus callosum was sectioned by passing the needle at a depth just below that of the corpus callosum from the splenium through the rostrum.

Training

Ss were pretrained to run to the goalbox, and to knock over grey stimulus cards which blocked the goalbox entryways. One eye was then covered with an opaque contact occluder, and the Ss were trained to discriminate between half-inch black and white stripes slanting 45° to the right or left. Twenty-five trials per day were given until a criterion of 18 correct responses in 20 consecutive trials had been reached, or until 300 trials had elapsed, then the occluder was shifted to the opposite eye and the Ss were trained again to criterion. After completion of training most Ss were given 20 trials with both eyes covered, affirming the reliability of the occluder.

RESULTS

Table I presents the 1st and 2nd-eye trials to criterion for each S categorized according to whether an uncrossed, a crossed system or both systems mediated the discrimination. In addition, the peak percentage correct in any block of 20 trials is given for Ss which failed to reach criterion before the 300-trial cut-off point.

There were 8 instances among the albino Ss and 6 among the hooded Ss in which vision was restricted to an uncrossed fiber system. Using the trials to criterion measure, there was no overlap between

Table I. Trials to Criterion for Albino and Hooded Subjects According to the Fiber System Employed During Training. (Percentage Correct for the Best 20-trial Block is given in Parentheses for Ss Failing to Meet Criterion)

	S	First Eye	Second Eye	S	First Eye	Second Eye
Uncrossed Fibers	A1	300*(55%)		H5	141	157
	A2	214	300*(85%)	H6	109	
	A4		300*(75%)	H7		1
	A5	300*(80%)	300*(75%)	H8		2
	A8	300*(75%)		H9	111	
	A9	300*(80%)				
Crossed Fibers	A1		165	H7	252	
	A6	199		H8	148	
	A9		45	H9		26
	A11	195				
Both Systems	A3	254	187	H1	78	3
	A6		22	H2	75	0
	A7		194	H3	105	35
	A8		127	H4	125	75
	A10	161				

* Failed to meet 18/20 criterion within 300 trials

albino and hooded rat uncrossed fiber performances, and the strains differed significantly with a $p = .002$ (Mann-Whitney U). Since both first and second eye performances are included here, it might be supposed that the difference was at least partially due to differences in the proportion of second eye performances, but even if we ignore second eye data altogether the two strains differed with a $p < .04$ (Mann-Whitney U = 0). Furthermore, a measure which ignores rate of acquisition and simply takes into account peak percentage correct in any block of 20 trials leads to the same conclusion. Using this measure, albinos differ from hooded Ss with a $p = .004$ (U = 3).

Examination of the peak percentage correct scores reveals that, in spite of the failure of albinos to discriminate at the criterion level, some learning occurred via uncrossed fibers. In fact, only one animal failed to reach the .05 level (15/20 correct) or better. Six of the 8 animals met the commonly used 9/10 criterion, the median trials to this criterion for all 8 cases being 168. However, these performances were not sustained. All Ss, regardless of strain, discriminated at criterional levels when using either a crossed fiber system or both systems.

DISCUSSION

There are variations in the acquisition of pattern discriminations corresponding to the differences in density of uncrossed fiber bundles in albino vs hooded rats. It is, therefore, likely that the contrasting interocular transfer performances of these two varieties of rat are founded largely on this simple structural variation. The direct visual pathways from a given eye in the albino rat terminate almost entirely in a single cerebral hemisphere, and monocular visual inputs are, therefore, isolated in a manner which, *mutatis mutandis*, makes the albino rat almost identical to the higher mammal whose optic chiasm has undergone midline sectioning. The failure of the corpus callosum to transmit veridical unilateral input to the opposite hemisphere remains an enigma.

It is probable that the differing evaluations of uncrossed fiber effectiveness previously reported by Chang (1936a,b) and by Muntz & Sutherland (1963) stem from the use of albino rats in the former experiment and hooded rats in the latter. As we might expect, (Chang, 1936a,b) found the uncrossed fibers "useless" in pattern discrimination, whereas Muntz & Sutherland (1963) found them quite capable of mediating

such discrimination.

Finally, it is suggested that further efforts invested in the examination of strain differences in brain-behavior relations would be well spent. Within a single species the transition from completely (in a functional sense) to partially decussated optic chiasm can be observed, and its significance evaluated. (It is by no means certain that this significance lies solely in the relative isolation of input.) Furthermore, it is clear that slight inter-strain structural variations can give rise to major behavioral divergences, and since several variations of this sort have already been described (see Lund, 1965), with perhaps still more waiting to be delineated, careful consideration should be given to the task of evaluating the generality of neuro-psychological findings obtained within a given strain.

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Note

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Simple and complex learning in rats reared socially or in isolation¹

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Male rats made hyperactive and sexually inept by rearing in isolation showed higher rates of response in a single response task and lower proficiency in a competing response situation than did normal, socially-reared litter-mates. These results and a marked reduction in errors on the competing response task by Ss of both rearing conditions which were more experienced in the conditioning situation confirm Spence's (1958), 1964 drive-anxiety theory.

In addition to being sexually inept, socially isolated rats, guinea pigs, and monkeys (Gerall, 1963; Valenstein, Riss, & Young, 1955; Mason, 1960) often are hyperactive in a mating situation. While neither etiology nor consequences of this experimentally induced hyperactivity have been fully explored, the possibility of integrating the above findings with one systematic series of hypotheses and laws is presented by Spence's theory of emotionally based drive (1958).

If it is assumed that the hyperactive Ss possess a high generalized drive state, they should, according to Spence (1958), attain higher performance levels sooner than lower drive, socially reared Ss when learning a single response task. When learning involves competing responses, however, acquisition rate should be faster for the lower drive Ss. Any situational variable which affects drive level at the time of acquisition should similarly influence performance. Ss unfamiliar with an experimental situation generally have a higher level of drive relative to sophisticated Ss (Spence, 1964). Since drives are assumed to summate, unsophisticated, socially isolated Ss should have the highest level of generalized drive and sophisticated socially reared Ss the lowest levels. In the present study, the extension of this theory to the performance of socially isolated and socially reared Ss was tested directly in an operant conditioning situation using two tasks involving different degrees of competing responses.

METHOD

Subjects

The six socially isolated Sprague-Dawley male rats serving as Ss were separated from their mothers and litter mates at 14 days of age and placed in individual air cooled styrene plastic 9 by 12 by 12 in. cages. Their first contact with another S occurred at 90 days of age, when each was given the first of nine 10-min. mating tests during a five-week period. Without exception the isolated Ss failed to copulate and exhibited hyperactivity. The six socially reared Ss, which were litter mates of the isolated Ss, were also removed from their mothers at 14 days of age and lived under identical conditions, except that two males and one

female lived together. All of the socially reared Ss mated normally and none was hyperactive. The Ss were between 150-175 days of age at the beginning of the learning phase. Isolated and social housing conditions were maintained, and all Ss were 22 hrs. food deprived throughout the study.

Apparatus

Foringer operant conditioning programming and recording units and a 10 by 9.5 by 11.5 in. environmental box with two manipulanda were used.

Procedure and Design

Three socially reared and three socially isolated Ss made up an experimentally naive group. Following acquisition of the bar pressing response, these Ss were allowed to respond for 150 45-mg food reinforcements on CRF for 10 daily sessions. During this period each S's bar of preference (i.e., the manipulandum pressed most frequently) was determined. From the 11th day on CRF onward, only the bar of preference was reinforced until the S made 10 or fewer responses to the non-reinforced bar while making 100 responses to the bar of preference on each of two consecutive days. The response contingency was reversed the following day, and the new contingency was maintained during daily sessions of responding for 100 reinforcements until the S made 10 or fewer responses to the non-reinforced bar on two consecutive days. This constituted the competing response task.

A sophisticated group formed from the remaining three socially reared and three socially isolated Ss was first allowed five days of responding for 150 45-mg food reinforcements on CRF, and then, 1-hr. periods of responding for five days on FI 12 sec., five days on FI 30 sec., and for 14 days on DRL 30 sec. The Ss were then returned to CRF for two days, and after each S's bar of preference was established, the reinforcement-of-bar-of-preference and competing response tasks were presented.

RESULTS

The time required to obtain 150 reinforcements during each group's first four days of training is shown in Fig. 1. Analysis of variance revealed that neither the interaction between groups and trials, nor the main effect of trials was statistically significant. The difference between socially isolated and socially reared Ss was statistically significant beyond the 5% level of confidence, the level used in rejecting the null hypothesis in this study. Thus, the isolated Ss required less time than the presumed lower drive, socially reared Ss to reach the performance criterion.

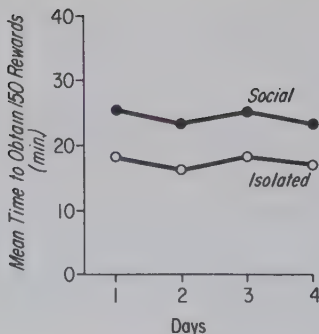


Fig. 1. Mean time required by social and isolated Ss to obtain 150 rewards on a crf schedule involving no competing responses.

The total number of errors made by the Ss before obtaining 100 pellets in the competing response task is shown in Fig. 2. The socially isolated Ss made significantly more errors before reaching the criterion of 100 reinforcements than did the socially reared Ss. Since the cumulative records indicate that the isolated Ss responded at a higher rate, it might be argued that number of errors on the competing response task is a linear function of response rate. To partial out the rate difference between the groups, analysis of covariance was performed with mean response rate on the first four days of CRF training as the predictor variable. The result was that the difference between the socially isolated Ss was increased rather than decreased.

Ss with the greatest amount of previous experience in the Skinner box switched to the new bar after signifi-

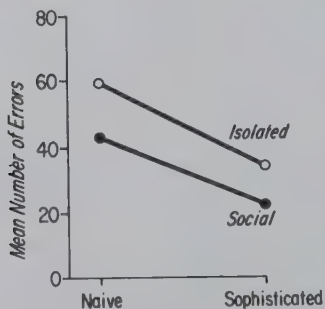


Fig. 2. Mean number of errors made by social and isolated Ss in bar pressing task involving competing response tendencies.

cantly fewer trials than the relatively naive Ss. The interaction between degrees of sophistication and conditions of early rearing was not statistically significant.

DISCUSSION

The results of this study generally confirm the predication made from Spence's theory of the effect of emotionally based drive on the learning of simple and competing response tasks. Ss reared in social isolation, which were assumed to possess higher drive than socially reared Ss, performed with higher proficiency than social Ss when a single response was required and were poorer on a task involving a competing response. The opposite results were obtained in the lower drive, socially reared Ss.

The variable of degree of previous training might be characterized as overlearning, or degree of sophistication or learning to learn phenomena. However viewed, the predictions generally remain the same: learning of a new task, whether or not it involves reversal, should be facilitated by previous experience. The results of this experiment are in accord with this prediction. While these data do not indicate whether the sophisticated Ss perform well because of increased habit strength or reduced drive, the results are clearly in accordance with Spence's suggestion that the sophisticated Ss will be hindered less by high drive states than inexperienced Ss.

Although relationships between high drive, an accompanying rise in anxiety, and deficit in sexual performance cannot be stated at this time, the data presented encourage further comparisons between the behaviors associated with rearing in isolation and those elicited from high drive or high anxiety Ss.

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Notes

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Classical appetitive conditioning in the pigeon: Partial reinforcement¹

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Light and food were paired for two groups of pigeons, one consistently and the other partially reinforced in an equated-reinforcements design. The over-all level of response to light (stabilimetrically measured) was the same in the two groups, both in acquisition and in extinction, although a significant Groups by Trials interaction appeared in extinction. The relation of these results to those of other experiments on partial reinforcement in classical conditioning is noted, and their implication for the problem of adventitious reinforcement is considered.

In a recent experiment on classical conditioning in the pigeon, a CS-US interval of 10 sec. was found to produce better conditioning than an interval of 1 sec. (Longo, Klempay, & Bitterman, 1964). The technique employed was to pair a CS with food and to measure the general activity which the CS came in consequence to evoke. The unusual outcome of the experiment suggested that adventitious reinforcement of response to the CS by the appetitive US might play an important role in the situation, the longer CS-US interval being assumed to provide greater opportunity for the operation of such a process. The results of the present experiment, in which the properties of the technique were explored further, bear on the validity of this interpretation.

Method

Six Ss are trained simultaneously in ventilated picnic chests. Each chest is divided into two compartments by a black Plexiglas partition. S's compartment is about 11 in. long, 11 in. wide, and 13 in. high. Its floor is a spring-mounted platform linked by a light rod to a phonograph cartridge fixed to the floor of the chest on the other side of the partition. To S, the partition displays only a feeding tray of white Plexiglas which can be illuminated with blue or white light, and into which about 2.5 gm of mixed grain can be discharged from a hopper by the action of a solenoid; hopper and solenoid, colored lamps, and associated wiring are mounted behind the partition. To measure S's activity during the CS-US interval or during control periods of no stimulation, the amplified output of the phonograph cartridge is used to drive a relay which operates one pen of an event-recorder. The pen rises at the start of the period in which activity is to be measured, falls momentarily as each unit of activity is generated, and then returns to the rest position at the end of the period. All of the events of the experiment are programmed automatically.

The Ss were 24 experimentally naive White Carneaux cocks reduced to 85% of their free-feeding weights on a 24-hr. schedule and pretrained to take food readily

from the blue-lighted trays in the conditioning chambers. In the experiment proper, the animals were trained in daily 15-'trial' sessions, with a mean intertrial interval of about 6 min. and a range of 2-10 min. On the first nine days of acquisition, all Ss were constantly reinforced; there were five reinforced conditioning trials and 10 interspersed activity 'trials.' The CS was a change in the color of the tray-light from dim blue to bright white, which was followed 20 sec. later by the presentation of food (US), whereupon the tray light became blue once more. The 20-sec. activity trials, on which neither the CS nor the US was presented, were used to obtain measures of basal activity.

On the basis of their performance in the first nine days of acquisition, the animals were divided into two equated groups of 12 Ss each, Consistent and Partial. The training of the Consistent Group continued as before on days 10-25, but for the Partial Group five unreinforced presentations of the CS were substituted for five of the activity trials. To begin with, the reinforced and unreinforced trials of the Partial Group followed each other in Gellermann orders (with a maximum of only three unreinforced trials in succession), but as training continued longer runs of unreinforced trials were introduced (4, 5, 8, 10, and 10 on days 13, 15, 17-18, 20-21, and 23-24, respectively). Both groups were extinguished on days 26-31, with five unreinforced presentations of the CS and 10 activity trials on each day.

Results

In Fig. 1, the course of acquisition and extinction in the two groups is plotted in terms of mean magnitude of response to the CS on each day, with mean magnitude of response on activity trials plotted for purposes

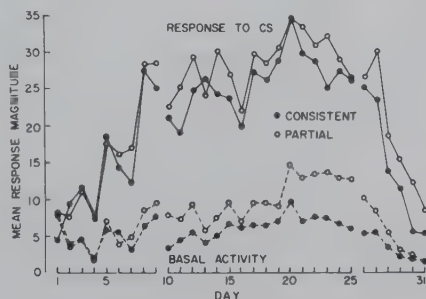


Fig. 1. Mean magnitude of response to the CS and mean basal activity in acquisition and extinction sessions.

of comparison. The curves for the second phase of the experiment (days 10-25) in which the two groups were treated differently are based on identical trials—the reinforced conditioning trials and the activity trials for the Partial Group. A Lindquist Type I analysis of response to the CS on acquisition days 10-25 yielded a significant Days effect ($F=5.06$, $df=5/110$, $p<.01$), but neither a significant Groups effect ($F<1$) nor a significant interaction ($F<1$). A Lindquist Type VI analysis of response to the CS in extinction also yielded a significant Days effect ($F=32.17$, $df=5/110$, $p<.01$), as well as a significant effect of Trials Within Days ($F=4.89$, $df=4/88$, $p<.01$). The Groups effect was insignificant ($F<1$), but evidence of greater resistance to extinction following partial reinforcement appeared in the form of a significant Groups by Trials interaction ($F=5.25$, $df=4/88$, $p<.01$). The nature of the interaction is shown by Fig. 2 in which mean magnitude of response to the CS is plotted over trials. On the chance that magnitude of response might be an insufficiently sensitive measure, magnitudes of response were converted to probabilities of response; a significant Groups effect failed to appear in any of four separate analyses with response defined as 5, 10, 20, and 30 units of activity, respectively (F -values ranging from less-than-1 to 1.49).

Discussion

The partial reinforcement effect has not appeared as dependably in classical conditioning situations as it has in instrumental situations. Greater over-all level of response in extinction after partial as compared with consistent reinforcement has been found in some experiments—with the African mouthbreeder by Gonzalez, Eskin, & Bitterman (1963) and with the earthworm by Wyers, Peeke, & Herz (1964)—but not in a substantial number of others. The results of a

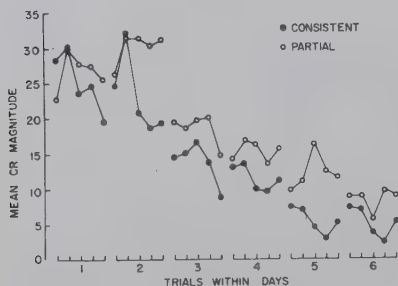


Fig. 2. Mean magnitude of response to the CS on individual extinction trials.

long series of experiments with the goldfish have been negative for the most part, although special schedules have in some cases given evidence of greater resistance after partial reinforcement which takes the form, not of a Groups effect, but of a Groups by Days or a Groups by Trials interaction (Berger, Yarczower, & Bitterman, 1965). An experiment with the rabbit has given entirely negative results (Thomas & Wagner, 1964), and two experiments with the dog have produced nothing but interactive evidence of the PRE (Fitzgerald, 1963; Wagner, Siegel, Thomas, & Ellison, 1964).

Whatever the reasons for these discrepancies, the present results closely resemble those of analogous classical conditioning experiments with the goldfish (Berger, Yarczower, & Bitterman, 1965) in which a CS was paired with shock and the general activity that it came in consequence to evoke was measured. Since shock cannot be thought of as adventitious reward for response to the CS, and since it is easy with a real response-reward contingency to produce the PRE in the pigeon (Roberts, Bullock, & Bitterman, 1963), we may doubt that adventitious reward plays a substantial role in the situation of the present experiment. Perhaps, then, an explanation of the unique results for CS-US interval which have been obtained in the same situation should be sought elsewhere.

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Note

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TCAP: Negative results in avoidance and water maze learning and retention¹

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The effects of TCAP, a compound reported to stimulate RNA synthesis, were studied in avoidance learning and water maze learning in rats. Contrary to a published study on avoidance learning and some unpublished data on water maze learning, neither situation revealed facilitation of acquisition or retention by TCAP.

The compound 1, 1, 3-tricyano, 2-amino, 1-propene (TCAP)² has been reported by Egyhazi and Hyden (1961) to produce an increase in the RNA and protein content of Dieters' nerve cells in the rabbit while reducing their content in associated glial cells and markedly altering the base composition of the RNA in the two cell types. The potential significance of this compound for molecular theories of learning and memory has led a number of investigators, in work thus far largely unpublished, to study its effects in various learning situations. The only detailed published report on behavioral effects of TCAP known to the authors is one by Chamberlain, Rothschild, & Gerard (1963) showing, among other findings, that retention of avoidance learning in rats is facilitated by a single intraperitoneal (i.p.) injection of TCAP on the first day of avoidance training. Among the unpublished studies is one by Essman (personal communication) showing facilitation of water maze performance in mice by chronic TCAP injections. In this report we present our results with TCAP in these two learning situations, both of which are basic training paradigms for long-term research programs.

METHOD

Experiments 1-3 were avoidance learning studies conducted in 4 identically-constructed shuttle boxes similar to those described by Brush (1962). Experiments 4-6 were water maze studies performed in the 6-unit T-maze described by Polidora, Cunningham, & Waisman (in press). Ss were male albino and hooded rats approximately 100 days of age.

Avoidance studies

In all three avoidance learning experiments the basic procedural sequence was pretest, injection, and first avoidance training session on Day 1, followed by a second avoidance session, without injection, on Day 2. In Experiment 3 a third avoidance session was given on Day 3 without injection.

Conditions common to these three studies were (a) compound CS (light plus white noise); (b) constant intertrial interval of 2 min.; (c) 5-sec. CS-US interval; (d) overlap and simultaneous termination of CS and US on escape trials; (e) 10-trial pretest immediately preceding the Day 1 injections, each pretest trial having a

45-sec. maximum duration; and (f) TCAP dose of 15 mg/kg (concentration 5 mg/ml) or an equivalent volume of vehicle placebo (benzyl alcohol, carbowax, and sodium hydroxide to adjust pH) injected i.p. 45 min. before avoidance training on the first experimental day only.

In Experiment 1, 16 hooded rats were given the pretest, injections (8 drug, 8 placebo), and 20 avoidance trials on Day 1, followed by 20 more training trials on Day 2. Shock intensity was .25 ma. Since the overall level of avoidance responding in Experiment 1 was low, the procedure was repeated in Experiment 2 with 24 additional hooded rats with the shock intensity increased to .3 ma. Thirty-nine naive hooded rats (13 given TCAP, 13 placebo, and 13 uninjected), were used in Experiment 3, and conditions were the same as in Experiment 2 except that three training sessions were administered, each consisting of 30 trials.

Water maze studies

In all three water maze studies, a 6-day procedure identical to that described by Polidora et al (in press) was used. Briefly, this consisted of straight alley training (1 day), 6-unit maze learning (3 days), and reversal (2 days, Ss run through the reverse maze route). In addition to the 6-day test, Ss in Experiments 4 and 5 were retested for retention 9 and 40 days later.

In Experiment 4, 12 hooded rats receiving 15 mg/kg TCAP and 11 saline control Ss were given 9 daily i.p. injections; 6 of these were given on the test days, 1 hr. before testing, and the remainder were given on the 3 days prior to testing. In Experiment 5, 10 hooded rats receiving 15 mg/kg TCAP and 10 saline controls were given 4 daily i.p. injections, 3 on the days preceding testing and 1 on the first test day only, again 1 hr. before testing. The Ss in Experiment 6 (13 albino rats on TCAP diet and 4 on control diet) were fed TCAP mixed in dry mash (0.5 gm/kg/day) or dry mash alone from weaning at 20 days of age through the last day of water maze testing, which was completed at approximately 100 days of age.

RESULTS

Avoidance studies

The results of the three avoidance experiments (1, 2, and 3) are presented in Fig. 1 in terms of mean percentage of avoidance responses. Inspection of the data from all three studies revealed no significant group differences in number of avoidance responses, latency of responding, or number of intertrial responses. The apparent differences on Day 2 of Experiment 1 (upper portion of the figure) and on both test days of Experiment 2 (middle portion) were largely the result of extreme

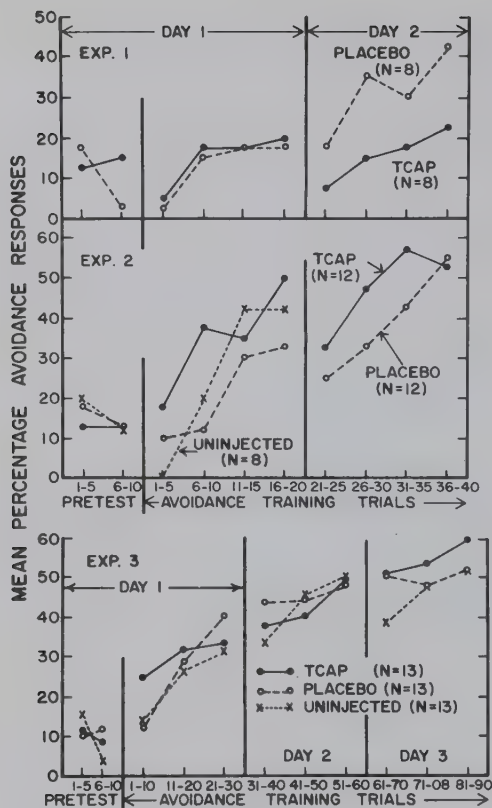


Fig. 1. Pretest and avoidance learning data from Exps. 1-3.

scores contributed by a single S in each of these experiments. Considering the larger Ns and the stability of the data, we regard the negative results of Experiment 3 (lower portion, Fig. 1) to be the most reliable. *Watermaze studies*

In Experiments 4, 5, and 6 no significant differences in errors or swimming speeds were found between TCAP-treated rats and controls in acquisition, reversal, or retention. The small but nonsignificant differences obtained were generally in the direction of superior performance by control Ss.

DISCUSSION

The avoidance learning findings contradict the results of Chamberlain et al (1963), who also used a TCAP

dose level of 15 mg/kg i.p. 45 min. before Day 1 trials and a highly similar training schedule consisting of three 25-trial sessions with a 2-min. intertrial interval. Other experimental conditions differed, however. The present studies were conducted in shuttle boxes whereas Chamberlain et al used a cylindrical bar-pressing apparatus. In addition, the training was preceded by a nonshock pretest in the present studies, whereas in their research it was preceded by 25 10-sec. shocks randomly administered in a plain cylinder. Other differences were that Chamberlain et al used a buzzer CS, 10-sec. CS-US interval, saline control injection, and albino rats. It is conceivable, though not readily understandable, that some combination of these differences could account for the discrepancy in results. In any event, while our data do not disprove the original finding of facilitation of avoidance learning by TCAP, they do indicate that, at best, it has remarkably limited generality.

The discrepancy between the present water maze results and the unpublished findings by Essman may be more understandable than in the case of the avoidance studies, in view of Essman's use of a higher dosage of TCAP (20 instead of 15 mg/kg) and longer periods (30-120 days) of drug administration prior to testing. Other unpublished evidence is accumulating at the Wisconsin Primate Center and elsewhere which indicates that rats' and monkeys' performance in various learning tasks may be facilitated by chronic, but not by acute, administration of TCAP.

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Notes

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2. This compound, 1, 1, 3-tricyano, 2-amino, 1-propene, a dimer of malononitrile, is also known by its Upjohn Co. designation, U-9189, and by abbreviations such as "tricyamp," "tri-a-p," and TCAP.

The hawk-goose phenomenon: A replication and an extension¹

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Mallard ducks, having no prior experience with objects passing overhead, were more active in the presence of the silhouette of a hawk than that of a goose. However, Ss were equally responsive to a triangle moving either base-forward or apex-forward. The results confirm earlier reports of the hawk-goose phenomenon, and cast doubt upon its explanation in terms of differences in the rate of change of visual stimulation produced by the two silhouettes.

Lorenz (1939) and Tinbergen (1948) reported that some gallinaceous birds exhibit escape reactions when the silhouette of a hawk is passed overhead, but not when the same silhouette is moved in the opposite direction, thus simulating the appearance of a goose. More recently, Melzack, Penick, & Beckett (1959) reported the differential reaction in mallards, which had no prior experience with objects moving overhead. Other investigators (Hirsch, Lindley, & Tolman, 1955; Rockett, 1955; McNiven, 1960) failed to confirm the findings in chickens and other species, but their techniques have been criticized by Tinbergen (1957) and Lorenz (1961). The present experiment was performed in an attempt to replicate the hawk-goose phenomenon in mallards, even though the birds had never seen objects moving overhead.

As a secondary purpose, the present investigation was also designed to test the hypothesis offered by Schneirla (1959, pp. 16-17) that the differential reaction exhibited by birds to the hawk and goose silhouettes stems not from the configurational properties of the silhouettes (e.g. short neck versus long neck, as suggested by Tinbergen, 1951, p. 77), but rather from the difference in the rate of change of visual stimulation produced by the two silhouettes as they pass overhead. Schneirla hypothesized that the blunt leading edge of the hawk pattern causes a more abrupt darkening of the visual field than does the relatively tapered leading edge of the goose pattern, and that the differential reaction of the Ss is produced by the resulting rapid *versus* gradual retinal changes. Such a consideration led Schneirla to suggest that a triangle moving base-forward or apex-forward might produce the same effects as do the hawk and goose, respectively.

Method

Nineteen mallard ducks (*Anas platyrhynchos*) served as Ss. They were hatched in an incubator, kept in a brooder for 14 days, and then maintained in an indoor pen, the construction of which prevented them from seeing flying objects, other than insects. The Ss were fed an ad libitum diet of Purina duck mash or pellets and

water. Testing occurred 44-47 days after hatching.

The amount of activity exhibited by Ss was measured in response to each of four test patterns: the silhouette of a hawk, the silhouette of a goose (i.e. the hawk silhouette flying backwards), a triangle moving base-forward, and a triangle moving apex-forward. The Ss received one test per day for four consecutive days, and the order of presentation of the test patterns was randomized over successive tests. The Ss were tested individually; those birds not being tested were kept in an adjoining pen, from which they could not see the test patterns.

A rectangular pen, measuring 70 by 30 in., served both as the rearing and testing site. The test patterns were presented to S by passing them 6 ft. overhead, along the long axis of the pen. The patterns were attached to a guy wire and pulley arrangement, which was moved by hand at the approximate rate of 1 ft. per second. Movement of the patterns always began at the same end of the pen, and the patterns were out of S's view at the beginning and end of each test. The Es observed Ss from behind a screen.

The floor of the test pen was divided into seven blocks, each measuring 10 by 30 in., and a test began only when S was standing quietly in one of the three center blocks. The dependent measure was the number of blocks S entered during the first 15 sec. after the test pattern came into view. A similar measure was used by Kratzig (1940), Hirsch et al (1955), and by Melsack et al (1959).

The test patterns used in the present experiment were made from heavy cardboard and painted flat black. The hawk-goose silhouette was closely patterned after one of several used by Tinbergen (1951, p. 78). Its wing span was 8 in. and the body measured 6 in. in length. The base and altitude of the triangle were 8 in. and 4 in., respectively. Since the area of the triangle exceeded that of the hawk-goose silhouette by a ratio of 1.5 to unity, the triangle could be expected to produce a greater change in visual stimulation, as it passed overhead, than did the hawk-goose silhouette. The ceiling of the room was painted flat gray, in order to provide reasonable contrast with the test patterns.

Results and Discussion

Table 1 shows the mean and standard error of the ranked activity scores exhibited by Ss in the presence of each of the four test patterns. Differences in activity scores attributable to treatments (i.e. test patterns) were statistically significant, as indicated by an analysis of variance of ranked data (X^2 ranks = 10.2, $df=3$,

Table 1. Means and Standard Errors of the Ranked Activity Scores in Response to the Four Test Patterns

	Hawk Pattern	Goose Pattern	Test Pattern	
			Triangle Base Forward	Triangle Apex Forward
Mean Rank	3.53	2.37	1.92	2.18
S. E.	0.16	0.18	0.14	0.16

Note. A high mean rank indicates a high level of activity.

$p < .02$). Moreover, the results of a Newman-Keuls test showed that the activity scores in response to the hawk pattern were significantly greater ($p < .01$) than those elicited by the other patterns, but observed differences in activity scores produced by the other three patterns were not significant.

The results of the present experiment confirm earlier reports that mallard ducks are more active when the silhouette of a hawk is passed overhead than they are when the same silhouette is moved in the opposite direction, thus simulating the appearance of a goose. The high level of activity produced by the hawk silhouette has been linked to the mallard's escape pattern (Kratzig, 1940; Tinbergen, 1957; and Melzack et al, 1959). This differential responsiveness to the hawk-goose silhouette is the more remarkable because the birds had no prior experience with objects moving overhead.

On the other hand, no significant difference was observed in the amount of activity exhibited by Ss in the presence of the triangle moving base-forward, as compared with the same pattern moving apex-forward. Therefore, since both triangles elicited about the same low level of activity as did the goose silhouette, it would appear that the birds were responding to a configurational property present in the hawk silhouette and absent in the goose silhouette and the triangles.

Tinbergen (1951, pp. 30-31 and 77-78) has suggested that the short neck of the hawk constitutes a sign-stimulus which releases the escape pattern in the mallards. However, the identification of the critical aspect of the hawk silhouette awaits the results of additional research.

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Note

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Effects of magnitude of reinforcement in *Macaca speciosa*¹

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Four adolescent stumptail monkeys were subjected to repeated shifts in magnitude of reinforcement (1, 3, or 9 pellets) while performing on a free-operant variable-interval reinforcement schedule. Rate-magnitude functions were found to be similar to those obtained with other primate and subprimate species.

The present study was undertaken to determine whether the stumptail macaque (*M. speciosa*), an Old World monkey species rapidly becoming well-known for its tameness and adaptability to behavioral test situations, exhibits a relation between instrumental performance and magnitude of reinforcement that is similar to that observed in rhesus monkeys (e.g. Schrier, 1965) and in subprimates (reviewed by Pubols, 1960). A secondary interest was to study the effects of adding external cues correlated with varying reward magnitude levels.

Method

Four adolescent female stumptail monkeys having a history of fixed-ratio, variable-ratio, and fixed-interval training were tested on a VI 1 (variable-interval of 1 min.) schedule in a Lehigh Valley 1469 test chamber. The chamber was equipped with a single (right-hand) lever, a 3-color cue light over the lever, and a dispenser for delivering 45-mg sucrose pellets. The experiment was automatically programmed such that reinforcing events could consist of from 1 to 9 pellets, delivered at the rate of approximately 4/sec.

Following stabilization of baseline lever responding reinforced by a single pellet (Phase 1), each S was exposed to daily shifts in reinforcement magnitude, between 1 and 9 pellets (2 Ss) or 1 and 3 pellets (2 Ss) for 12 sessions (Phase 2) and among 1-, 3-, and 9-pellet levels for an additional 18 sessions (Phase 3). In Phase 4, 18 more sessions like those of Phase 3 were given, except that each of the three magnitude levels was associated with a particular cue-light color (red, green, or white) flashing at a 10/sec. rate throughout the session. Sessions were 35 min. long in these four phases.

Phase 5 consisted of 12 34-min. sessions, in each of which there were three 10-min. "baseline" periods separated by two 2-min. "probes." In the baseline periods the usual VI 1 conditions and cues-magnitude correlation prevailed, with daily shifts as in Phase 4. The probes consisted of nonreinforced presentations of the two cue-light colors not associated with the baseline magnitude of a given session. Thus, for example, a given session could consist of 10 min. of VI baseline

responding under "green" reinforced by 3 pellets, followed by 2 min. of "white" (normally associated with 1 pellet), followed by a return to the baseline for 10 min., followed by 2 min. of "red" (normally associated with 9 pellets), followed by a second return to the baseline for the final 10 min. of the session. On a different day the same S could have "white, 1-pellet" baseline conditions and "red" and "green" nonreinforced probes.

Results and Discussion

Individual plots of lever-pressing rate as a function of reward magnitude in the last 30 min. sessions of Phases 3 and 4 showed, in general, the negatively accelerated function typical of magnitude studies with other species. In Phase 4 (cues added) the function also tended to appear consistently within the first 5 min. of the sessions whereas this was not the case in Phase 3 (no cues); this difference failed to attain statistical significance, however.

Group-average rate measures plotted as a function of successive periods within sessions in Phases 3-5 showed rate declines similar to those obtained by Schrier (1965, Fig. 3) for rhesus monkeys reinforced on VI 30" by varying concentrations of liquid sucrose, and there was further agreement with Schrier's data in that the amount of decline tended to be inversely related to reward magnitude. Individual plots, however, showed pronounced declines for two Ss (49 and 57) and no decline for the other two.

The data obtained in Phase 5 (cues and probes) are summarized in Fig. 1. In this figure the mean lever-pressing rates in the VI baseline periods (4 sessions and 3 10-min. periods within sessions combined for each point) are depicted by the larger symbols connected by heavy solid lines. These baseline values were similar to the rate measures obtained in Phases 2 and 3 so that this portion of Fig. 1 may be regarded as representative of the individual rate-magnitude functions found in the experiment as a whole. Analysis of variance applied to the Phase 5 data revealed a significant main effect of reward magnitude ($F=9.09$, $df=2/6$, $p<.05$).

The rate measures obtained in the 2-min. probe periods of Phase 5 are represented in Fig. 1 by the smaller symbols, with arrows indicating the baseline conditions surrounding a given probe. All 4 Ss showed response rates under probe stimuli associated with 1 and 3 pellets on 9-pellet baseline days that were higher than the baseline rates on 1- and 3-pellet days. Moreover, 3 of the 4 Ss, when given a probe stimulus associated

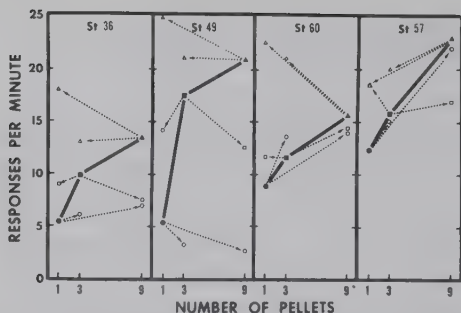


Fig. 1. Response rates of the 4 Ss in VI-reinforced baseline periods (larger symbols with solid connecting lines) and unreinforced probe-stimulus periods (smaller symbols) during Phase 5.

with 1 pellet on 9-pellet baseline days, displayed higher response rates during the probe stimulus than during the immediately adjacent baseline periods. This finding held up when the comparison was made with those portions of the baseline periods in which reinforcement setups occurred 2 or more minutes apart (such intervals occurred 3 times in every 20 min. of the VI tape). In other words, on 9-pellet baseline days the Ss tended to increase their rates above normal levels when given probe stimuli signifying smaller reward magnitudes, and did so to an extent which suggests that performance in the presence of a probe stimulus was determined by something more (a frustration factor?) than lack of discrimination between baseline and probe stimuli. Although variability in the data rules out support for this phenomenon in the form of statistical significance

and caution is in order, we consider the finding sufficiently interesting to warrant further study.

Because we expected that consummatory time would vary directly with reward magnitude as manipulated in this study, we gave considerable attention to the length of postreinforcement pauses in the cumulative record of lever-pressing and frequently observed consummatory behavior in the test chamber. Typically Ss took all pellets from the food cup within 2 or 3 sec. after delivery, stuffed them into their food pouches, and quickly resumed lever-pressing, such that the difference in postreinforcement pausing between 1-pellet and 9-pellet sessions was too small to warrant correction of rate measures. Squirrel monkeys apparently behave in a quite different fashion under similar circumstances. In an unpublished study (Goodrich, Rhoads, & Davenport) comparing 1-pellet and 4-pellet performance on a free-operant VI 1' schedule, 4 adult female squirrel monkeys exhibited reinforcement pause lengths and qualitative consummatory behaviors that were markedly different for the two reward magnitudes, necessitating supplementary recording and correction of rate measures.

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Notes

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2. Now at Macalester College.

Incubation of anxiety as measured by response suppression¹

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Rats were given 6 days of operant bar training, 1 session of avoidance training, and differential rest intervals of 0, 1, 4, 24, and 168 hr. Ss were then tested in the operant training situation where rate suppression during avoidance CS presentation was used as an index of fear. Fear increased up to 4 hr. and diminished only slightly after 1 week.

Kamin (1957) measured the retention of an incompletely learned avoidance response. In a shuttle box, he gave his six groups avoidance training, differential retention intervals of 0, 1/2, 1, 6, 24 hr., and 19 days, followed by 25 identical relearning trials, the performance during which constituted a measure of CR retention. Kamin found that retention was a curvilinear function of delay with the minimum falling at 1 hr. To explain this phenomenon, now known as the "Kamin effect," he suggested two underlying processes. The decrement up to 1 hr. represents forgetting of the response while the rise in the curve after 1 hr. indicates incubation, a "jelling" of the avoidance response.

Since that time, other authors (e.g., Brush, Myer & Palmer, 1963; Denny, 1958; Denny & Ditchman, 1962; Denny & Thomas, 1960, and others) have replicated the effect but have attributed the relearning decrement to response competition brought about by the disruptive effects of fear. That is, fear stimuli in the situation elicit responses (e.g., crouching) which are incompatible with the act of shuttling. Denny has suggested that fear incubates during the 1 hr. delay and subsequently dissipates whereupon relearning is not impaired at 24 hr. Following Brush (1962) it would seem useful to dichotomize the stimulus complex in avoidance conditioning into two components—the apparatus cues and the CS. Using this distinction, the apparatus cues are responsible for eliciting competing responses in the "Kamin effect." CS fear, on the other hand, as a source of motivation for the avoidance response, may incubate as well but yield a different function.

The purpose of the present study then was to test changes in CS fear over time. Although several studies have reported that incubation does occur (e.g., Brady, 1952; Bindra & Cameron, 1953; Golin, 1961; McMichael, 1965, and others) a systematic study of fear changes is lacking.

In order to test incubation of fear to the CS independent from those of the apparatus cues, it seemed appropriate to use a conditioned emotional response (CER). Here, the fear CS is presented in a new situation not directly related to avoidance acquisition, thus minimizing the effectiveness of irrelevant fear cues.

The extent to which ongoing habit (bar pressing) is disrupted is the index of CS fear.

Subjects

The Ss were 70 male albino rats of the Wistar strain and were purchased from the Manor Farms Breeding Colony. Estimated ages varied from 50 to 70 days, and their pre-experimental weights ranged from 195 to 300 gm. Ss were given ad lib feeding for 5 to 10 days after which they were reduced to 80% of their body weight and maintained on a 23 hr. feeding schedule. The Ss were divided into 7 groups of 10 each.

Apparatus

The operant training apparatus consisted of a modified Skinner box (Plexiglas) which contained a 2-in. bar placed 3-1/2 in. above the grid floor. To the right of the bar was a cup into which a Gerbrands food dispenser delivered .045 gm. pellets (J.P. Noyes & Co.). A standard 6 volt electric buzzer was centered at the base of the back wall. The entire box was placed inside a sound insulation chamber which was equipped with a 10 w. bulb for illumination and a ventilating fan. The box was wired so that food reward could be given on a variable interval (VI) or 100% schedule, or by manually operating a microswitch. The VI schedules were programmed by a Gerbrands tape puller.

The avoidance training apparatus was a tilt cage, 20 in. long, 5 in. wide, 11-1/2 in. high. One hundred gm., 2 in. on either side of the center pivot was sufficient to depress a microswitch located under the frame of the grid floor. The cage was also placed in a sound insulation chamber containing a fan but with no light. An identical buzzer was placed on the bottom of the back wall of the tilt cage.

Procedure

On day 1, Ss were first allowed to eat five pellets in the Skinner box followed by 1/2 hr. of bar shaping. On days 2 through 6, Ss received 1/2 hr. per day of bar training. A VI-.25 schedule was employed on days 2 and 3 while on days 4, 5, and 6, reinforcement occurred on a VI-.5 schedule.

On day 7, Ss received avoidance training in the tilt cage which consisted of 3 min. of adaptation followed by a maximum of 30 avoidance trials. The shock intensity was .5 ma., the CS-US interval was 5 sec., and the intertrial interval was 1 min. The CS, buzzer, was terminated by an avoidance crossing or at the onset of shock, whichever occurred first. An escape response terminated the shock. After a criterion of three successful avoidances in 30 trials was reached, Ss were replaced in their home cages for the inter-session interval (ISI). Five experimental groups (A) received delay intervals of 0, 1, 4, 24, and 168 hr. (1 week), after which time they were tested.

Two additional control groups were run. Group C-1 received 15 CS presentations in the avoidance box and had a delay interval of 1 hr. Group E-24 on the other hand received 12 unsignalled shocks (shock omitted on trials 8, 12, and 15) and had a delay of 24 hr. This procedure was followed since mean number of CS-US presentations for the experimental groups was found to be 15, mean 1st, 2nd, and 3rd avoidances appearing on trials 8, 12, and 15, respectively. All other conditions (operant training and testing) were identical for these groups.

Following the ISI, all groups were tested in the Skinner box for an additional 1/2 hr. The test was divided into three 10 min. periods. During the first 10 min., no CS was presented. This period established a post-shock level of responding against which the rate for periods 2 and 3 were compared. The 5 sec. avoidance CS was then presented once per min. during periods 2 and 3. The measure of response suppression was obtained by computing each S's rate during periods

2 and 3 separately as a percentage of its rate during period 1. Food was delivered on a VI-5 schedule during the test.

Results

For all groups, mean operant rate for the last day of training, and mean number of CS-US pairings were computed. An analysis of variance was applied to each set of data separately and no significant differences were found. Differences during testing then, are presumably due to the different delay periods.

Rate for each group during period 2 is given as a mean percentage of period 1 (baseline) in Fig. 1. A Type I analysis of variance was applied to these data. The groups effect, $F=2.85$, $df=6/63$, $p<.025$; the measures effect, $F=72.02$, $df=1/63$, $p<.001$; and the interaction, $F=5.26$, $df=6/63$, $p<.001$; were significant.

Using appropriate t tests, it was found that for period 2, all groups differed from C-1 except E-24. A-0 and A-1 did not differ significantly from each other or from E-24. A-4 and A-24 were found to differ from all groups except A-168. Since no significant differences in suppression were found between any groups for period 3, these data are not discussed. They merely indicate that all groups recovered to their former level of responding.

Discussion

From these results, it can be concluded that fear, as measured by response suppression, increased over time up to 4 hr. and decreased only slightly after 1 week. In part, this function is similar to the one obtained in the "Kamin effect," if one may assume that Kamin's decrement represents an increase in fear. The two functions disagree, however, on the point at which fear begins to dissipate. Apparatus fear, the source of response competition in the "Kamin effect," is minimal by 24 hr. allowing effective avoidance relearning. However, fear of the CS as shown in this study does not diminish by 24 hr. The present results also disagree with McMichael (1965, exp. II). Using a similar design, he found that suppression increased

up to 6 hr., but was not significantly different (from the 0-delay condition) at 24 or 504 hr.

The cause of incubation of fear is a matter of some speculation. On the basis of these results, it would be difficult to support the disinhibition theory suggested by Golin (1961) and others. Rate of avoidance learning did not vary significantly over groups nor was there any adaptation to the situation. Thus it is unlikely that differential amounts of inhibition could cause differences in suppression over groups.

The cognitive theory suggested by Saltz & Asdourian (1963) seems equally inappropriate to account for the present results. That fear alters the stimulus situation may be the case, however, incubation of fear does not seem to be limited to generalized stimuli as indicated by the findings of Brady (1952), McMichael (1965) and the present study.

One promising series of findings was reported by Brady (1958). He found that physiological changes occurring after the psychological stress of avoidance account for ulcers in monkeys. That acidity secretion increases during rest as a function of time would suggest that incubation of fear may be a correlate of the same physiological mechanism—acidity content itself functioning as an internal stimulus for fear.

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Notes

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2. Now at Princeton University.

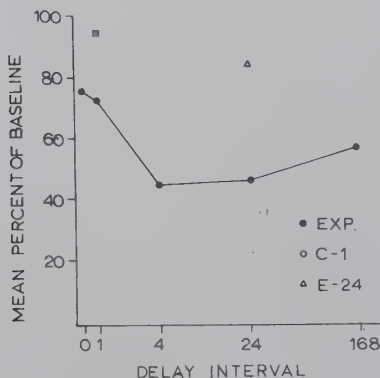


Fig. 1 Mean percentage of baseline for period 2.

Affect conditioning associated with the onset and termination of electric shock¹

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The results of this study are consistent with the position that fear is more readily conditioned to a cue paired with the onset rather than the offset of a painful event. No evidence was found for the presumed secondary reinforcing properties of a cue associated with shock termination.

It is generally agreed that a stimulus paired with shock-induced pain acquires the capacity to elicit fear. There is, however, no unanimity of opinion regarding the conditions necessary for the learning of the fear reaction. Mowrer (1960) maintains that the association between an initially neutral cue and fear is formed solely on the basis of the repeated contiguity of the cue with the onset of pain. From a strict reinforcement theory, on the other hand, it follows that the reduction in drive afforded by the offset of the painful event is critical for the acquisition of fear (cf. Miller, 1951). The primary purpose of the present study was to examine the relative merits of these alternative views. A secondary objective was to explore the possibility that there is conditioned to a cue associated with shock termination not fear but "hope"—an affective state with reward value.

Method

The Ss were 180 experimentally naive, male albino rats, approximately 90 days old. For 7 days prior to the experiment proper, Ss were maintained on a 23 hr. food deprivation schedule and habituated to handling.

A 3-stage experimental procedure was employed with 1 day devoted to each stage.

1. *Training.* Ss, all 23 hr. hungry, were trained in a modified Skinner-box, 28 by 10 by 6 in., painted flat black. Depression of a food-trough located at one end of the chamber granted access to food pellets. To establish a base level of performance, Ss were permitted 30 reinforced trough presses. The base rate (in responses/min.) was determined for the 2-min. period preceding the final minute of training.

2. *Affect conditioning.* For one-half the Ss, affect conditioning was conducted in the chamber previously described; for the remainder, in a cylindrical compartment, 10 in. in diameter and 6 in. high, painted flat white. Each S was clamped in position with its tail extending through an opening in the chamber wall; AC current (average intensity, .63 ma.) was delivered to electrodes fixed to S's tail. Behaviorally induced fluctuations in current intensity were thereby eliminated. The CS—a 2 sec., 4-cps interrupted buzzer—was presented in either an onset or an offset

position. In the former case, the CS occurred 1 sec. before the onset of the 7-sec. shock and extended for 1 sec. into the shock period; in the latter, the cue was presented 1 sec. before and continued for 1 sec. after the termination of the US.

3. *Testing.* All Ss were tested in the chamber used for training. The trough-pressing response gave access to food and, simultaneously, produced the cue previously associated with shock. The interrupted buzzer continued to sound until the trough was released. Ss were given a 10-min. period of free responding timed from the first press. A test response rate was determined for the final 9 min. of the test period to assess the effect of the experimental variables on the preshock level of performance.

The experimental design afforded an evaluation of the effects of four orthogonal variables: (1) temporal relation of cue to shock (onset or offset); (2) number of affect-conditioning trials (1, 4, or 10); (3) strength of hunger drive during testing (3, 6, or 23 hr. of food deprivation); and (4) similarity of the affect-conditioning and testing environments (identical or dissimilar). Five Ss were assigned at random to each of the 36 treatment combinations of the design.

Results and Discussion

The rationale for the inclusion of the onset-offset dimension is apparent. It permits a test of Mowrer's contention that the contiguity of a cue with a drive-increment is sufficient for the learning of fear. The number of affect-conditioning trials was varied to provide a specification of strength of fear independent of the crucial temporal parameter. The common assumption that strength of fear is indexed by performance decrement during testing cannot be granted *a priori*; it requires confirmation within the context of the present procedure. Strength of hunger drive during testing was investigated in recognition of the possibility that the effect of the feared cue might vary as a function of the strength of the approach tendency to the trough. Fear, for example, may serve to inhibit a weak response tendency but to facilitate a strong one. Finally, similarity of the affect-conditioning and testing environments was varied in the attempt to institute the condition presumed by Mowrer to favor the demonstration of the secondary reward—or conditioned hope—properties of an offset cue. If the reward value of such a cue consists in its capacity to evoke a conditioned relaxation of fear, this value might be demonstrable only when fear is present during testing, that is, when the similarity of the affect-conditioning

and testing chambers permits ready generalization of fear from the former to the latter.

Changes in response rate from training to testing are noted in Fig. 1. Analysis of differences in mean response rate revealed a statistically significant decrement in performance— $F=185.54$, $df=1/144$, $p<.001$. The degree of response inhibition was an increasing function of the number of affect-conditioning trials— $F=6.58$, $df=2/144$, $p<.005$ —and a decreasing function of the strength of hunger drive during testing— $F=11.75$, $df=2/144$, $p<.001$. No significant interaction between the latter variables was observed. Of major concern, the performance decrement associated with the onset cue exceeded that associated with the offset cue— $F=5.63$, $df=1/144$, $p<.025$. The difference in the inhibitory effects of these cues was constant over all levels of the remaining variables.

These results must be interpreted with some caution. The significant decrement in performance is not attributable to the effect of the cues paired with shock alone; for two-thirds of the Ss, the hunger drive during testing was considerably reduced over that current during training. The absence of interactions among variables, however, suggests that the effects of onset and offset cues differed in degree but not

in kind. And the presence of a significant performance decrement— $F=31.79$, $df=1/48$, $p<.001$ —for those Ss both trained and tested while 23 hr. hungry bolsters the argument that the effect was an inhibitory one.

In sum, the findings support the conclusion that the strength of fear conditioned to a cue is reflected in the degree of inhibition of a response producing that cue. Since the decremental effect of the cue paired with shock onset exceeded that of the cue paired with shock termination, it may be inferred that fear was conditioned more strongly to the former. This inference is clearly consistent with Mowrer's position that the contiguity of a cue with the onset of a painful event is sufficient for the acquisition of the fear reaction. The force of the argument is somewhat diminished by the recognition of at least two potential sources of confounding: (a) during affect conditioning, the onset cue may have been more perceptible than the offset cue; and (b) skeletal responses of differential incompatibility with trough-pressing may have been conditioned to the two cues during the course of affect conditioning—say, "freezing" to the onset cue and "tugging forward" to the offset cue.

With regard to the second objective of the study, the results afford no support for the proposition that a cue in repeated contiguity with the cessation of a noxious state acquires reinforcing properties. The cue paired with shock offset failed to facilitate performance even when Ss were affect conditioned and tested in the same environment, a condition presumed to favor the demonstration of secondary reward value for an offset cue.

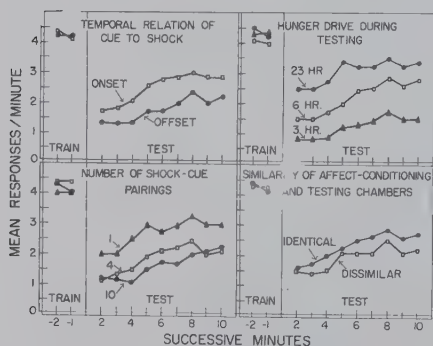


Fig. 1. Mean response rate over the 2 min. preceding the final minute of training and over the final 9 min. of testing plotted for each value of the four experimental variables.

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Note

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Preference for fixed vs. variable amounts of reward¹

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In a concurrent, two-choice situation pigeons match their relative frequency of responding both to relative frequency and relative amount of reward. In a related situation involving secondary reinforcement, pigeons prefer variable over fixed interval schedules of primary reinforcement. The present experiment found little evidence for a similar preference for variable vs. fixed amounts of reward, suggesting that pigeons integrate amount of reward in a simple, linear fashion.

Pigeons may be trained to peck at either of two response keys. When switching from one key to another is never reinforced ('change-over delay') the relative frequency of pecking on each key may be controlled by a variety of independent variables. One such variable is the relative frequency of reinforcement for pecks on each key. If responding is reinforced on a variable-interval schedule, the relative frequency of responding on each of the keys comes to match the relative frequency of reinforcement (Herrnstein, 1961). The reinforcement in question may either be primary or secondary.

In the latter situation, when pecks at either of two response keys occasionally produce a stimulus in the presence of which further pecks occasionally produce food, pigeons show a preference for variable (as opposed to fixed) interval schedules of primary reinforcement (Herrnstein, 1964). This preference is shown as a higher relative frequency of responding on the key producing the secondary reinforcer associated with the variable-interval schedule of primary reinforcement.

In addition to reinforcement frequency and variability in reinforcement frequency, a third parameter, amount of reinforcement, affects the relative frequency of responding in this situation. If responding on one key produces occasional reinforcements consisting of 3 sec. access to grain while responses to the other produce reinforcements consisting of 6 sec. access, pigeons tend to respond twice as frequently on the second as the first (Catania, 1963). In this respect, therefore, amount of reward is analogous in its effects to frequency of reward. A natural extension of these results is an experiment to investigate the variable vs. fixed amounts (i.e., durations of access to grain) of reinforcement upon preference in the two-choice situation.

Method

The Ss were two male, White Carneaux pigeons, maintained at 80% of their free-feeding weights.

The experimental chamber was a two-key version of the conventional Skinner box for pigeons, made by the Grason-Stadler Co. Except for condition VI, the left key was always green and the right red. Effective responses produced an audible 'feedback' click. During the presentation of the reinforcer the house and key lights were turned off and the magazine aperture illuminated. Sessions ended after 60 reinforcements.

Pecks on each key were reinforced according to independently-programmed, identical variable-interval schedules with a mean interreinforcement interval of 1.5 min. The first response on one key following responding on the other started a timer which prevented reinforcement on that key for a period of 1.5 sec. Switching from one key to the other was therefore never immediately followed by reinforcement.

After 13 training sessions during which approximately equal responding was established to both keys, the sequence of conditions described in Table 1 occurred.

Condition I was a control condition to see whether identical magazine cycles (reward presentation times) on each key would yield the expected equality of responding. Condition II varied the distribution of magazine cycle times on the right key, keeping the mean of the distribution at 3 sec., equal to the magazine cycle on the left key. Condition III still further increased the variance of the distribution of magazine cycle times on the right key. Condition IV varied reward magnitude alone, and conditions V and VI further investigated the effect of variability, controlling for position and/or color preference.

Results

The effects of the conditions are indicated in Fig. 1. The only condition which produced a clearcut effect

Table 1. Order and Duration of Experimental Conditions

Condition	Magazine cycle duration		Sessions
	Left Key	Right Key	
I	3 sec.	3 sec.	24
II	3 sec.	Mean 3 sec. (2,5,4,1,3,4,2,3)	7
III	3 sec.	Mean 3 sec. (9,1,1,1)	8
IV ¹	2 sec.	4 sec.	17
V	3 sec.	Mean 3 sec. (9,1,1,1)	40
VI	Mean 3 sec. (9,1,1,1)	3 sec.	16

1. Conditions for bird 437; reversed for bird 435.

The sequence of successive magazine cycle durations is indicated by the numbers in parentheses.

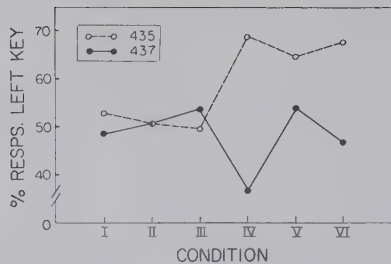


Fig. 1. Mean percent responses on the left key for the last 7 days of each condition.

is condition IV in which the relative frequencies of responding for both pigeons changed in the expected directions by approximately the expected amounts. Thus, bird 435 responded 69% of the time on the left key (expected: 67%) while bird 437 responded 37% (expected: 33%) on the left key in approximate agreement with the matching found by Catania (1963).

Conditions II, III, V and VI, the variability conditions, show little effect of the independent variable. For bird 435 conditions II and III show negligible preference for either key, and the left key preference shown in conditions V and VI seems attributable to the effect of reward magnitude in condition IV. Only the directions of change of preference between conditions are consistently related to the independent variable; thus, between conditions I, II and III the variability of reward duration on the right key increased and preference shifted successively in the direction of that key. Similarly, between conditions V and VI the variable key shifted from right to left and preference also shifted in that direction (the absolute preference in both these conditions was for the left key, however).

Bird 437 shows results of the same general kind, close to indifference between the two keys in conditions II and III and little change between conditions V and VI. In terms of direction of change, the picture is similar to 435, but in the opposite direction.

Four conditions in this experiment involved variability in amount of reward. These four conditions allow us to examine three transitions from one level (more or less variability) or position (left variable vs. right variable) of this parameter to another. These transitions are from conditions I to II, II to III and V to VI. Since each bird may prefer either the fixed or the variable key, there are 4 possible outcomes indicating

some consistent effect of the independent variable. Since there is a total of 6 transitions for the two birds, yielding 64 possible outcomes (each transition can produce a change in preference towards either fixed or variable keys), the probability of a consistent effect is only 1/16 by chance alone. We cannot, therefore, entirely exclude the possibility of a small effect of variability on each of the two birds.

Discussion

The concurrent situation, in which Ss may choose to make either of two responses at any time, is a sensitive measure of preference, provided switching from one response to the other is never reinforced (Herrnstein, 1961). Using this procedure with two pigeons we found no substantial effect of variability in reward presentation time on preference. The effectiveness of the situation was demonstrated by a condition in which the mean reward presentation time differed on the two keys. The birds adapted to this change by shifting to the key giving longer access to the reward, in approximate agreement with the matching found by Catania (1963). This condition showed that these pigeons were sensitive to the reward-presentation-time dimension. The next two conditions (V & VI), which were replications of the previous variability condition, still failed to show substantial effects of the independent variable; although further analysis indicates that variability may exert a small, idiosyncratic effect.

Herrnstein (1964) found that pigeons show a preference for variable as opposed to fixed interval schedules of reinforcement. One implication of this result is that the function relating frequency of reinforcement to rate of responding is not linear: response rate is controlled by some other measure of reinforcement frequency than the arithmetic mean under these conditions.

The results presented here suggest that the opposite is true of reward magnitude; over the range investigated pigeons appear to integrate reward presentation time in a simple linear fashion.

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Note

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Irrelevant stimuli present all or half of the time as subsequent discriminanda¹

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Irrelevant stimuli each associated with a 50% reinforcement schedule were either present on all or on half of initial discrimination training trials. For different groups in test problem training a previously irrelevant stimulus was either the positive or the negative discriminandum, with a novel stimulus as the other discriminandum, or both discriminanda were novel stimuli. No effect due to novelty was demonstrable. Ss were retarded in test learning if their test negative discriminandum had been present on half of the initial acquisition trials; no other groups differed from controls.

It is now clear that stimuli may acquire discriminative control over responding even though the reinforcement schedules associated with their presence differ from the conventional 100% or 0% (e.g., Babb, 1956; Jeeves & North, 1956; Sperling, 1962, for previously irrelevant cues as subsequent discriminanda; Erlebacher, 1963; Grosslight, Hall, & Scott, 1954; Kendler & Lachman, 1958; North & McDonald, 1962; Pavlik & Born, 1963, for discrimination learning with intermittent schedules of reinforcement for responses to the positive discriminandum, the negative discriminandum, or both). However, the specific conditions under which irrelevant stimuli become discriminative are not specifiable from these data; the present experiment was designed to examine some of these conditions.

Method

The Ss were 46 naive male hooded rats, approximately 90 days of age. The data for two additional Ss were discarded since they died during the experiment.

The apparatus was two elevated platforms enclosed in a cubicle compartment divided by a partition into starting and stimulus sections. When S broke an infrared light beam at the terminal end of the starting platform, a 100-w bulb over the stimulus compartment was turned on and a timer was started which stopped when S stepped off the stimulus platform.

A 20-v light bulb centered on a swinging door at the terminal end of the platform could be either on (L) or off (D). Four different stimulus platforms covered with 1 in. Mystic Tape were used: Checkerboard (C) made of alternating black and white squares; Stripe (S) made of alternating longitudinally laid black and white tape; Zigzag (Z) made of alternating black and white diagonals laid from the longitudinal center; and Gray (G) made of longitudinally laid gray tape. The ratio of black to white in the areas of the first three platforms was about equal within and among platforms.

A 23 hr. deprivation schedule was maintained through-

out 12 days of pretraining and the experiment. All Ss received initial training on a (L+D-) discrimination problem to a criterion of not more than one trial in a day on which the latency of response in the presence of the negative discriminandum was shorter than any latency of response in the presence of the positive discriminandum. There were six positive and six negative trials per day in random order on a 10-min. intertrial interval. A food cup was baited with two 94 mg Noyes pellets on positive trials; it was not present on negative trials.

Subgroups of Ss had different stimulus platforms present during this training. For Group C (N=16) the C platform was present on each trial; for Group Z (N=14) the Z pattern was present on each trial; for Group CZ (N=8) the C platform was present on half of the L and half of the D trials each day (three each) and the Z platform was present on the other trials; for Group CS (N=8) the arrangement was the same except that the S platform was used in place of the Z.

On the day following their criterion day on the L vs. D problem, each S began test problem learning. The swinging door containing the light bulb was removed from the apparatus. All procedures remained the same, and training was given to the acquisition criterion.

Half of the Ss were presented with a problem in which C was the positive discriminandum and G was the negative (C+G-); for the other half of the Ss S was positive and C negative (S+C-). These groups were constituted as follows: Half of training Group C went into each test problem (C/C+G-) and (C/S+C-); half of training Group Z went into each problem; (Z/C+G-) and (Z/S+C-); training Group CZ was given the S vs. C problem (CZ/S+C-); and training Group CS was given the C vs. G problem (CS/S+G-).

Results

Mean trials to criterion for the two problems are presented in Table 1, ordered with respect to test learning. There were no differences among the six experimental groups on trials to criterion on the L vs. D problem ($F=2.14$; $df=5/40$; $p>.05$). An analysis of

Table 1. Mean Trials to Criterion on Acquisition and Test Problems

Problem	Groups					
	(CZ/S+C-)	(C/C+G-)	(CS/C+G-)	(Z/S+C-)	(C/S+C-)	(Z/C+G-)
Acquisition of L+D-	106.5	132.0	115.0	82.3	94.5	108.0
Test	84.0*	54.0	52.5	51.4	48.0	39.4

* This mean is significantly different from each of the others in the row ($p<.01$)

variance for test problem learning yielded $F=9.10$; $df=5/40$; $p<.001$. The differences between these means were tested by 99% confidence intervals using Tukey's test. Group (CZ/S+C-) was significantly retarded in test problem learning compared to all of the other groups which did not differ from each other.

Analyses of transformed latency scores (log lat) indicated that terminal acquisition response levels in the presence of the C and Z stimuli did not differ among the group. There was also no apparent difference in latency of response to C on the first day of test problem training (both Fs were less than one), even though C was a novel stimulus for two of these groups—(Z/C+C-) and (Z/S+C-). Mean log lat for S and G on the first test day differed neither from each other ($F=1.27$; $df=5/40$; $p>.20$) nor from mean log lat for C (difference $t=2.54$; $df=5$; $p>.05$).

Mean log lat within each group on the second test day indicated that only Group (CZ/S+C-) was still responding faster on negative than on positive trials.

Discussion

If certain conditions of prior experience with a stimulus lead to the acquisition of discriminative control over responding by that stimulus, differences should be observable in the performance of groups who have had the necessary prior experience compared to those who have not. Neither Group (Z/C+G-) nor Group (Z/S+C-) had had any prior exposure to the two sets of test problem discriminanda. Group (CZ/S+C-) was the only experimental group which differed from them in test learning, and it was significantly slower.

Resistance to extinction in the presence of C seems to account for the retardation of this group which persisted longer in responding faster to C than any other group. The discriminative control over responding exhibited in resistance to extinction must have been acquired during initial training as a consequence of C being an intermittent feature of the initial environment. Group (C/S+C-) for which C was a constant feature also associated with a 50% reinforcement schedule did not show any effect in learning of the same test problem, and Group (C/C+G-) did not show any effect in learning a different test problem. These data, therefore, extend previous findings that a constant feature of the environment does not appear to acquire discriminative control over behavior (e.g., Ferster, 1951; Sperling & Birch, 1960) and that a stimulus that has been one of two previously irrelevant stimuli on a 50% reinforcement schedule does acquire such control (Sperling, 1962).

However, C was also an intermittent feature of the initial environment for Group (CS/C+G-) which received the same initial treatment with respect to C as

did Group (CZ/S+C-) but did not differ from the control groups in test learning. That it did not is perhaps an artifact of the test conditions for this group. Since Ss were responding asymptotically fast to the two discriminanda at the start of test learning, the mastery of the test problem was indexed primarily by increases in latency on (G-) trials rather than further decreases on (C+), thus making it unlikely that any effect of the initial treatment would be demonstrable in faster responding to C. Therefore, these data seem most clearly to suggest that resistance to extinction may provide a more sensitive index of prior treatment effects than acquisition functions in the single-stimulus apparatus. This has been observed previously (Birch, Ison, & Sperling, 1960).

The lack of any observable effect due to novelty of the test stimuli argues against its contributing to the experimental results. The use of several different stimuli in different combinations for training and test argues against differential generalization gradients as contributing to the data.

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Note

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Effect of continuous vs. discontinuous shock on shuttle box avoidance in the rat¹

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Discontinuous shock (.2 sec. on and 2.0 sec. off) was compared with continuous shock in a shuttle box avoidance situation using rats as subjects. Ss were shown to give a significantly larger number of avoidance responses when discontinuous shock was used as the US.

D'Amato and his associates (D'Amato et al, 1964; Biederman et al, 1964; D'Amato, in press) have repeatedly shown that discontinuous shock is a more effective US than is continuous shock in a discriminated lever press avoidance situation. As D'Amato points out, this finding presents some difficulties for most theoretical accounts of avoidance learning. It therefore seems important to determine whether discontinuous shock is more effective than continuous in other avoidance tasks. This study compares the effects of two types of shock on shuttle box avoidance learning.

Subjects

Thirty-three naive albino male rats from the Carnegie Tech colony were used. All Ss were 84 to 96 days of age at the beginning of the experiment. The discontinuous shock group had 17 Ss, the continuous shock group 16.

Apparatus

The avoidance box consisted of an alley 20-1/2 in. long, 11-1/4 in. wide with walls 16-1/2 in. high. The interior of the box was painted gray. The floor consisted of 2 grids of equal size made of 1/8 in. brass rods spaced 3/8 in. apart on center. They were hinged at the ends and suspended by springs in the center so that the weight of the rat on the grid activated a microswitch. An Applegate stimulator, Model 228, was used to charge the grid. Shock was scrambled with a relay type scrambler (Hoffman & Flesher, 1962). The top of the alley was covered with 1/8 in. Plexiglas. A 15 watt bulb was located in the center of each end of the box 11 in. above the grid. Two 4 in. speakers (used alternately) were mounted 7 in. behind the center of the box. A masking noise of approximately 69 db was produced by a blower. The CS, a 600 cycle tone, was generated by a Hewlett-Packard sound generator. The CS produced a total sound level of about 83 db as measured inside the avoidance box with a General Radio Company Sound Survey Meter, type 1555A. A control apparatus located in another room automatically timed and presented the events in the avoidance box.

Procedure

Ss in the two groups were run alternately and differed only in the type of shock. For the discontinuous shock

group the shock was on for .2 sec. and off for 2.0 sec. For the continuous shock group, the shock was uninterrupted. The shock level for both groups was 1.5 ma. On the first day of training, the Ss were selected at random from a group cage and placed in a single cage which then became the home cage for the rest of the experiment. Food and water was available in the home cage ad lib throughout the entire experiment.

At the beginning of training, the light over the right-hand grid was on. The S was placed on the lighted grid facing away from the dark grid. On the first trial, the tone sounded, the light over the right grid went out and at the same time the light on the left grid went on. After a 10 sec. interval, the dark grid was charged with a current of 1.5 ma. Shock remained on the dark grid until the beginning of the next trial. The tone was terminated as soon as S ran to the lighted grid. On each subsequent trial, the light shifted, the tone sounded, and the entire grid was free of shock for a 10 sec. period followed by shock on the dark grid. The intertrial interval was 15 sec. Each S was given 30 trials per day for 5 days.

An avoidance response was defined as a response of crossing from the dark grid to the lighted one within 10 sec. of the presentation of the tone and the changing of the lights. On such a response, S did not receive shock. If S delayed responding for more than 10 sec. it received shock and the response was defined as escape. Spontaneous crossings (i.e., between trials) dropped out quickly because the dark grid was always charged between trials.

Results

An analysis of variance test on the proportions of avoidance responses in 10-trial blocks showed a difference due to the type of shock stimulus. The mean percentage of avoidance responses for the discontinuous shock group (57.8%) was greater than for the continuous shock group (36.7%), $F=7.28$, $df=1/31$, $p<.05$. There was no significant interaction between the type of shock stimulus and blocks of trials.

Figure 1 shows the mean percentage of avoidance responses within 10-trial blocks through the course of learning. The means for the discontinuous shock group are consistently higher than the corresponding means for the continuous shock group.

Discussion

The results clearly show the superiority of discontinuous over continuous shock in the shuttle-avoidance situation. Whether this superiority will hold when other avoidance procedures are used remains to be

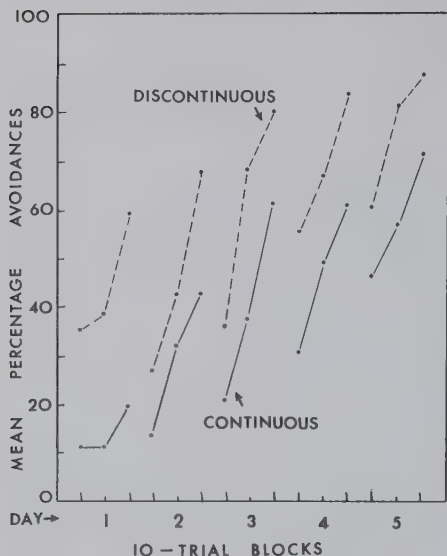


Fig. 1. Mean percentage of avoidance responses plotted in blocks of 10-trials for both the discontinuous shock group (N = 17) and the continuous shock group (N = 16).

Continued from page 172.

hypothesis of ECS effects, at least four points should be clarified. First, how do muscular or emotional tensions or their lack produce a competition with performance which simulates the existing interpretation of an inability of ECS-treated patients to recall elements of word lists? The supposedly "relaxed" subjects were able to gain sufficient strength to sincerely say, "I don't remember." Second, how is it that extreme emotionality is conditioned so easily to cues outside the apparatus but not to the apparatus itself? Should we postulate yet another gradient of conditioning for these extra-apparatus events? Third, since the statement is made that an ECS study using multiple treatments is not relevant to consolidation theory, further investigation of this moot point is badly needed. Hudspeth, McGaugh, & Thompson (1964) have found results interpretable as amnesic after several ECS treatments were given to the animals. Lastly, when, if ever, are changes in the CER in any species of animal causally related to avoidance performance?

If these very fundamental questions are answered experimentally, I would acknowledge the existence of a new interpretation of ECS effects (Lewis & Maher, 1965). Until then, the reader might be interested in another hypothesis (Hudspeth & Gerbrandt, 1965) consistent with the effects observed in human patients, with phenomenal emotionalities in extra-apparatus

seen. Observation of the Ss seems to indicate that the short bursts of shock produced less freezing and fewer perseverative scrambling and bar-biting responses than did the uninterrupted shock. The discontinuous shock did, however, seem to facilitate locomotor responses. Thus, discontinuous shock may facilitate avoidance learning because it moves the required locomotor response up on the Ss response hierarchy and increases the probability that the response will occur and be rewarded. If this is the case, it might be expected that discontinuous shock would be a less effective US in conditioned emotional response (CER) training and in passive avoidance learning when the measured response is one of inactivity.

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Note

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situation, with dissociations between CER effects and avoidance performance, and with neuroanatomical functions related to ECS effects.

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Sucrose reinforcement thresholds for hungry, thirsty, and non-deprived rats¹

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Sucrose reinforcement thresholds were determined for bar pressing. Hungry Ss showed lower thresholds than non-deprived Ss and thirsty Ss did not prefer sucrose at all.

Hungry rats have lower sucrose thresholds than non-deprived rats (Campbell, 1958) and bar press at higher rates for sucrose reinforcements (Collier, 1964). Thirsty rats prefer sucrose to water in brief exposure tests (Beck et al, 1965) but bar press no more for sucrose than for water (Beck, 1963; Collier, 1964). In the present experiment rats bar pressed in alternating time intervals for 1 or the other of 2 different solutions (water vs. sucrose), compromising the usual 2-choice preference situation and the single stimulus reinforcement situation. The object was to examine the thirsty rat's behavior more carefully, comparing water deprivation with food deprivation and no-deprivation conditions.

METHOD

Subjects

The Ss were 9 male albino rats about 100 days old.

Apparatus

Three identical Skinner boxes, previously described (Beck, 1963) were used. A telegraph key lever inserted through the front panel of each was the bar. Next to each side wall in the front panel was a hole 1.5 in. by 2.0 in. leading to a minibox through the bottom of which a dipper could deliver about 0.1 ml of fluid. On a given day 1 dipper delivered sucrose solution and the other delivered distilled water. In alternating 2-min. intervals 1 dipper operated on a VI-15" schedule and then the other. A light in the minibox signaled which dipper was functioning in a given interval.

Procedure

The Ss were extensively pretrained with water reinforcements while water deprived. Each was then tested while food deprived (FD), water deprived (WD) and non-deprived (ND) with each of 6 comparative (Co.) stimuli; 1%, 3%, 9%, 18%, 27% and 54% sucrose (weight/volume). Subgroups of 3 Ss each were subjected to the 3 deprivation conditions in counterbalanced order, with complete threshold determinations made for each S under his particular deprivation condition at the time. The Ss were adapted to a 23.0-hr. food deprivation schedule, a 23.5-hr. water deprivation schedule or ad lib food and water for 5 days prior to the start of each threshold series. On the last 2 days of each adaptation to schedule the Ss bar pressed for 1% vs. 54% sucrose, the extremes of the Co. stimuli. Each series took 12 days, 2 consecutive days for each Co. stimulus (counter-

balancing position). The order of the Co. stimuli within each series was randomly determined. On each day Ss bar pressed for 13 2-min. intervals on each dipper, but data from the 1st pair were not counted since Ss were learning the stimuli at this time.

RESULTS

The results were analyzed for both individual and group thresholds. Threshold functions are plotted in Fig. 1 and the threshold values summarized in Table 1.

Individual thresholds were determined for each S by the method of constant stimuli. For each Co. stimulus the percentage of the 24 paired intervals in which S bar pressed more for 1 stimulus than the other were calculated. Each threshold was then determined by linear interpolation as that concentration "preferred" in 75% of the pairs. A preference in 18 of 24 pairs is

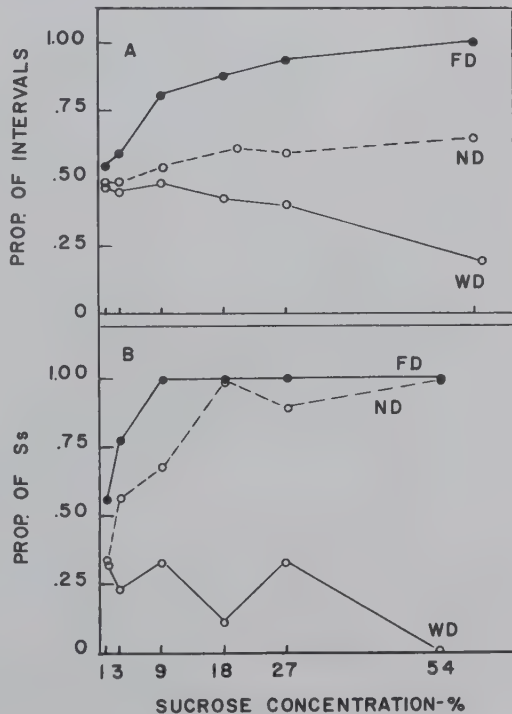


Fig. 1. Threshold functions for each deprivation condition. Panel A is the mean percentage of paired intervals in which Ss responded more for sucrose than water. Panel B is the percentage of Ss responding more for sucrose than water in their paired intervals.

Table 1. Mean individual thresholds and group thresholds

Threshold Procedures	Conditions		
	FD SUC > HOH	ND SUC > HOH	WD HOH > SUC
Individual	9.7%	* ---	** ---
Group (1)	2.8%	11.3%	17.2%
Group (2)	1.7%	7.4%	33.5%

* Only 3 Ss showed thresholds: 16.9%, 54% and 54%

** 5 Ss showed thresholds: 18%, 20.5%, 40.5%, 41%, and 46.7%

significant at the .01 level with a sign test. The functions are shown in Panel A of Fig. 1. Only under the FD condition did all Ss show a threshold value. Under WD, 5 of the 9 Ss showed a threshold for water over sucrose and no S showed a threshold under the ND condition.

Group Thresholds for the 9 Ss were determined in 2 ways. (1) They were estimated as the concentration where 75% of the Ss responded more for 1 stimulus than the other in more than half their 24 paired intervals. The functions are plotted in Panel B. Threshold values are considerably lower than found for individual thresholds. This is not surprising, of course, since a less stringent criterion was used. Thresholds were obtained for all conditions with this measure. (2) Group thresholds were also estimated as that concentration where 75% of the Ss gave more than 50% of their total responses for one stimulus over the other. The thresholds for the FD and ND conditions are lower here than for either of the previous two procedures (see Table 1). The threshold for the WD condition is higher than above, but this is due to minor variations enhanced by the small number of Ss.

DISCUSSION

The thresholds obtained here are considerably higher than those reported for 2-bottle preference tests (about 0.2% for hungry Ss, Campbell, 1958; about 0.4% for non-deprived, Burright & Kappauf, 1963; Beck et al., 1965) but are in agreement that the thresholds are lower under food deprivation than non-deprivation. The absolute values of reinforcement thresholds may well be functions of such variables as size, frequency, and effort to obtain the reinforcements, as well as the exact method of calculation. This remains to be determined.

The fact that the Ss did not respond more for sucrose than water under the WD condition generally corroborates previous bar pressing results but leaves unexplained the 1.2% preference threshold for sucrose over water found by Beck et al. The present study was designed to produce a within-session contrast but, of course, was not identical to the 2-bottle situation where judicious selection from the tubes may provide a heightened contrast effect, mouth rinsing, or dilution, not possible even in the bar pressing situation used here.

Examination of the 1st or 2nd pair of intervals each day generally showed results consistent with the results for the whole session. For example, all the Ss hungry bar pressed more for 54% sucrose than water in the 1st pair of intervals (means of 27.9 and 7.8 responses). Such immediacy of differential reinforcing effects further indicates the importance of taste factors in the control of behavior. When hungry, sucrose is more acceptable and reinforcing to the rat; when thirsty, water increases in acceptability and reinforcing efficacy. The declining sucrose preference under the WD condition may also be partly due to post-ingestional osmotic effects since the decline begins to appear above 9% sucrose, the isotonic concentration. The results are generally consistent with hedonic theory (Young, 1961) and suggest that food and water deprivation differentially set some kind of biasing mechanism to alter the acceptability (and reinforcing functions) of water and sucrose solutions.

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Note

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Age differences in lightness perception'

JACOB BECK

HARVARD UNIVERSITY

Adults and children made lightness judgments of targets in light and in shadow when the targets were presented singly and mounted together on a chart. The adults showed greater constancy than the children when the targets were presented simultaneously on a chart. Presented singly, however, the differences between the adults and the children were not statistically reliable. These results indicate the importance of the cues in the perceptual situation in relation to developmental differences in lightness perception.

Studies of lightness constancy as a function of age have produced varying results. Brunswik (1956, p. 83) reports an increase in constancy between the ages of 3 and 11. Burzlaiff (1931) substantiated an increase in constancy with age when a single color wheel was used, but found that the age trend disappeared when the standard and comparison stimuli consisted of a series of grays on a chart. Developmental differences apparently depend on the perceptual situation. To investigate this question, adults and children made lightness judgments of targets in light and in shadow when the targets were presented (a) singly and (b) simultaneously on a chart.

Method

The experiment was conducted in a darkroom. The targets were chips, each 1-1/4 by 1-1/2 in., ranging from white to black. Their reflectances were: 5, 10, 32, 63, and 100 percent. These chips were placed on a background either singly or as a group mounted on a cardboard backing in an irregular order. The background was a 4 ft. square board covered with black cloth and placed perpendicular to the O's line of sight at a distance of 46 in. A shadow caster invisible to O partially shaded the background. The illuminance of the illuminated part of the background was 1.5 ft.-c. and of the shaded part of the background was .85 ft.-c. The presence of the shadow was heightened by placing white, gray, and black papers (7 by 1-1/2 in.) on the background so that they lay half in light and half in shadow.

The plan of the experiment was to present O with the chart and the single chips shadowed and illuminated. There were four experimental conditions: (a) chart illuminated, (b) chart shadowed, (c) chips illuminated, and (d) chips shadowed. The shaded and illuminated locations on the background were chosen so that they were equally distant from the white, gray, and black papers and from the O. The same Os were run in all the experimental conditions. A balanced order was, therefore, employed with one-quarter the Os beginning

with each condition first. The illuminated and shaded conditions, however, were run consecutively. A typical experimental sequence, for example, was: the chart in light, the chart in shadow, the chips in shadow, and the chips in light. Each O made two matches of each of the five targets. If an O's two lightness matches of a target differed by two or more steps on the comparison chart, a third match was obtained. The geometric mean of an O's matches was taken as representative of his lightness judgment. The order of presentation of targets within a condition was always randomized.

Fifteen adults and 15 children served in the experiment. The children ranged from 5 years 0 months to 6 years 5 months with a mean age of 5 years 9 months. The adults were college students. Each O was seated in front of a table on which was placed a comparison chart of 10 chips ranging in approximately equal visual steps from white to black. The illuminance of the chart was 1.4 ft.-c. The instructions were as follows: "I am going to show you small squares of different colors. Sometimes the squares will be stuck together like this (show the chart), other times they will be alone like this (show individual squares). I would like you to tell me the color of each square. When I show you one of them, I would like you to look at the chart in front of you and point at the one that is most like the one on the board." To familiarize the Os with the task, 3 gray chips of lightnesses not used in the experiment were presented first.

Results

The geometric means of Os' lightness matches are presented in Figs. 1 and 2. Both the adults and the children made relatively accurate judgments of the lightnesses of the targets on the chart when illuminated. The single chips, however, are consistently matched to comparison targets with higher reflectances. This is not unexpected, since single chips on a black background would tend, on the basis of contrast, to be lighter than the grays on the comparison chart. Constancy of lightness occurs if Os despite the differences in luminance between the targets in light and in shadow match them to the same grays on the comparison chart. It may be seen from Figs. 1 and 2 that on the whole Os' lightness matches in shadow fall below their matches in light. Table 1 shows the number of times that adults and children judged the shadowed targets darker than the illuminated targets. A Chi-square test of the difference in the total number of times the shadowed targets were judged darker by adults and by children on the chart is significant at the .01 level. It

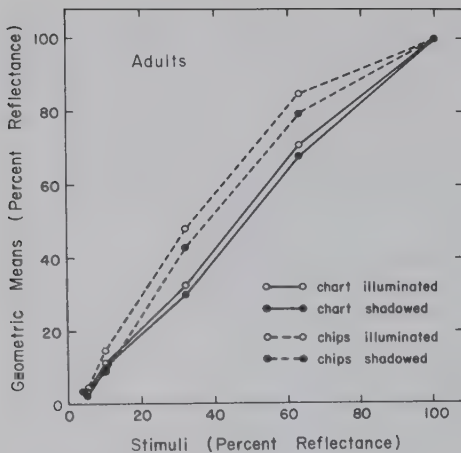


Fig. 1. Lightness judgments of the adults.

should be noted that both adults and children showed constancy on the white target (reflectance 100 percent) and tended not to show constancy on the black target (reflectance 5 percent). The difference between the adults and the children occurred on the gray targets. A Chi-square test of the difference in the number of adults and children reporting the shadowed target darker on the single chips is not significant.

Discussion

The results of the experiment indicate the importance of the cues in the perceptual situation for developmental differences in lightness perception. The results, however, differ from those of Burzlaff (1931). Burzlaff found that adults showed greater lightness constancy when a single target was presented but that both adults and children showed constancy when charts of grays were used. This discrepancy may be due to the fact that Burzlaff ran his experiment in an ordinary room where the cues for illumination would be greater than in the darkroom where the present experiment was con-

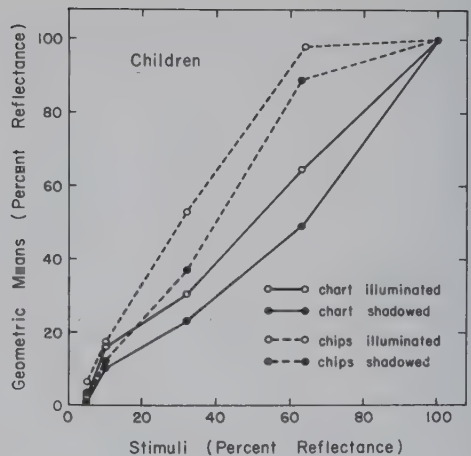


Fig. 2. Lightness judgments of the children.

ducted. In general, the results show that age differences in lightness perception may be expected depending upon the clarity and complexity of the cues indicating the illumination distribution in the field. What cues are responsible for the greater constancy adults exhibited on the chart is not clear. Perhaps the presence of the white target on the chart, which always was judged correctly, provided adults, but not children, with an anchor enabling them to make more constant lightness judgments. Whatever the true explanation for the change produced by the chart, the results show that the cue properties of stimuli may influence whether a variation in luminance is seen as a difference in the illumination of a surface or as a difference in the lightness of a surface. This is consistent with the findings of Beck (1965) and Fieandt (Brunswik, 1963, p. 125-127).

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Notes

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Table 1. Number of Times the Shaded Target was Judged Darker than the Illuminated Target

	Chart					Chips				
Percent Reflectance	5	10	32	63	100	5	10	32	63	100
Adults	10	5	5	6	0	11	10	8	5	0
Children	8	12	12	13	0	12	10	11	6	1

Perceptual behavior of 8- to 10-week-old human infants¹

ALFRED LANG

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The perceptual behavior of 8-, 9-, and 10-week-old infants as a function of different stimulus forms, individuality, and activation level was observed by means of a time-sampling rating method. The proportion of variance accounted for by differences between stimuli is found to increase with age; at the same time the effect of autonomic activation processes is decreasing. At 10 weeks but not at 8 weeks of age, circular forms elicit a relaxed approaching tendency, in contrast to a tense aversion, which is elicited by irregularly-shaped forms.

When confronted with a sudden and slightly intense, but otherwise unspecified visual stimulus, an infant reacts in a characteristic manner (Meili, 1957). After an initial motor inhibition some of the infants quickly recover, seem to enjoy the unusual stimulation, smile and attempt to grasp; with other infants the initial irritation grows into a state of heightened tension, and ends with motionless staring, aversion of the head, or sometimes, frightened crying. Both, intuitive global judgments and behavioral criteria (eye blink rate and course and amount of movement), mainly based on motion pictures, have been used to describe and measure the reaction (Lohr, 1960). It was conceptualized as a differential psychological continuum of "irritability" or "positive vs. negative attitude towards the outer world." The reaction at 3 to 4 months allowed the prediction of the behavior of the same children in different situations until at least their 8th year (Lang, 1962). It seems to involve both hereditary and environmental determinants (Lohr et al, 1964).

In an attempt to analyze more closely the general psychological meaning of this reaction, the present investigation used a somewhat complex, yet practicable, observation method based on these earlier studies. The perceptual behavior of 29 infants of both sexes as a function of individuality, activation level and different stimuli was studied in a three-way analysis of variance design at each of three age levels.

Method

Dependent Variable. Beginning with the presentation of the stimulus, the behavior of the infant was rated every 10 sec. on a 9-point scale of pleasurable relaxation vs. aversive tension. Low scale values include smiling and tendency to orient towards the stimulus; high values include either motionless tension or convulsive movements, crying, anxious mimic, and/or head aversion. Neglecting the time-dependent course of the reaction (which will certainly be essential in a more thorough analysis based on a more exact

method) all the ratings during each 3- (occasionally 2- or 4-) min. stimulus presentation were averaged and multiplied by 100, making for a Relaxation-Tension score with a theoretical range between 100 and 900. The correlation between the scores of two observers, one of them not aware of the nature of the stimuli, was $r = .88$.

Independent Variables. (1) Individual infants were allotted values of one variable in accordance with the above mentioned importance of individual differences. But no attempt was made in the present context to identify the continuum. Infants' parents were contacted by letter and phone; the experiments took place in their homes at a day when the infant was ± 2 days of the desired age. (2) As a rough approximation of activation level the state of the infant before and after the meal was used, assuming higher activation before and lower activation after the meal. (3) The stimulus forms reproduced in Fig. 1 were presented, one at a time, as a bright figure on a medium-grey screen, 25 cm above the eyes of the infant lying in its crib. The visual angle was approximately 19° ; area and contour length of the 4 forms were equal. The stimuli were selected to represent (a) degree of regularity, orderliness, or redundancy (circular vs. irregular form), and (b) the aspect of continuity vs. discontinuity (line vs. points) which has produced differences in fixation preference (Graefe, 1963).

Results

The Relaxation-Tension scores of independent samples at three age levels were separately analysed and the variance components of the significant effects ($p < .01$) calculated. The percent components are presented in



Fig. 1. The 4 stimulus forms, circle, irregular curve, circular points and irregular points, arranged for the aspects of regularity and continuity.

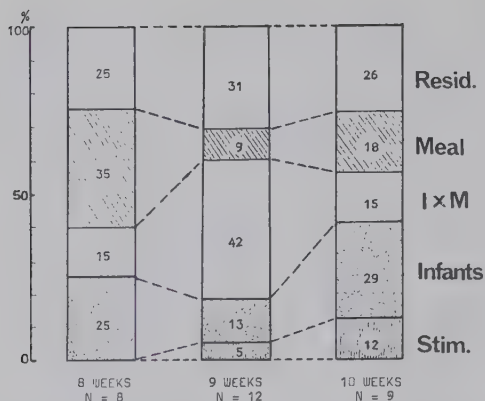


Fig. 2. Percentages of significant ($p < .01$) variance components in three-way analyses of variance at 3 age levels.

Fig. 2, giving a developmental picture of the relative importance of the analysed conditions of perceptual behavior.² Individual differences account for approximately one fourth of the variance. The proportion of variance accounted for by differences between stimuli is found to increase with age from zero to 12%. At the same time the effect of autonomic activation processes (Meal) decreases from one third to one fifth. As it was expected the higher activation level leads to a more tense reaction, the overall means before meals being 647, 601, and 598 for 8, 9, and 10 weeks respectively, as compared with 514, 539, and 511 after the meal. The overall means for the different stimulus forms are presented in Fig. 3. A clearly developing differentiation between the circular and the irregular forms is evident, indicating a more relaxed approaching tendency toward the "good" forms in contrast to a more tense aversion from the "bad" forms at 10 weeks. No significant differences are found for the stimulus aspect of continuity. At the age of 8 weeks no differential

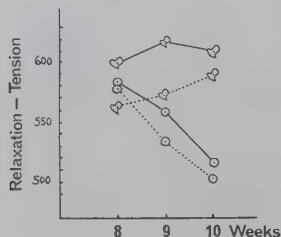


Fig. 3. Relaxation-Tension averages for the 4 stimulus forms at 3 age levels. Circular and irregular forms are indicated and connected by either a continuous line or points according to the nature of the stimuli. The null hypothesis of no difference between single stimuli is rejected for circular points vs. irregular curve at 9 weeks and for both circular forms vs. both irregular forms at 10 weeks (Duncan's Multiple Range Test).

perceptual behavior towards the four stimulus forms could be established by the present method.

Discussion

The results might be explained in the context of a System Theory of behavior and personality which elaborates Lewinian thoughts (cf. Lang, 1966). It is assumed that, in the absence of existing traces of external patterns, the incoming information is integrated into one of two inborn response classes which are further developed under the influence of experience (see also Schneirla, 1965). One of these is initially constituted by aversion tendencies and the expression of nuisance, the other by approach tendencies and the smiling response. These response tendencies provide a basis for the development of the motivational system. In addition, the approach tendency is considered crucial in the development of the perceptual-cognitive organization of the personal world, of which the distinction of regular forms may be one of the earliest instances. The postulation of an autochthonous component in the processing of incoming stimulation seems warranted, since it is not feasible to assume more experience with circular forms during the 9th and 10th week than with our irregular shape resembling a nipple. Emphasis is also put on individuality and on environmentally stirred and/or damped activation, both influencing the building up of the motivational and the perceptual-cognitive systems.

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Notes

- This investigation is a contribution to the Bernese Longitudinal Studies in Personality Development. It was conducted at the Psychological Institute of the University of Bern, Switzerland. The author wishes to express his indebtedness to Richard Meili. Thanks are due to Leonard J. Goldsmith for assistance in style. For a detailed exposition of theory, method, results and discussion of further problems, among them the relationship between the present method and the method of preferred fixation customary in infant perception research, the reader is referred to Lang (1966).
- At 9 weeks the Infant by Meal interaction component seems to be large at the cost of the respective main effects. This is probably due to sampling bias and should be interpreted with caution, although it leads to interesting speculations and further questions (cf. Lang, 1966).

The effects of alcohol on semantic and phonetographic generalization¹

C. MICHAEL LEVY AND PATRICK H. MURPHY, III
UNIVERSITY OF FLORIDA

One group of normal college males was given a moderate amount of alcohol prior to conditioned discrimination training of a voluntary response. A control group was given a placebo drink. The Placebo Ss later showed the usual superiority of semantic over phonetographic generalization. Alcohol completely reversed this relationship.

The purpose of the present experiment was to test the hypotheses that alcohol would increase the amount of phonetographic generalization (PG) and decrease the amount of semantic generalization (SG) found in normal adults. It has been known for some time (Riess, 1946) that young children display more generalization to words phonetographically related to CS words than to those semantically related, and that in normal adults the opposite trend appears. This reversal in trend is usually explained in terms of the growth of inhibitory tendencies toward PG with the development of strong language habits. The explanation is difficult to test directly, but two recent findings lend some indirect support. Schwartz (1960) found that normal adults given injections of chloral hydrate show, in the drowsy state, more PG than SG. Peastral (1961) observed that certain adult schizophrenics, characterized by poor inhibitory control, also evidenced the child-like pattern of generalization.

If, in fact, the orthogonality in generalization between children and adults is due to the latter's inhibiting phonetographically mediated responses, then presenting an inhibition-reducing stimulus to adults should increase the occurrence of PG and perhaps decrease the frequency of SG. The inhibition-reducing stimulus selected for use in the present experiment was ethyl alcohol (Hetherington & Wray, 1964; White, 1956).

METHOD

Apparatus

The S sat in a sound-shielded room about 5 ft. from an 11 by 18 in. screen. Beneath the screen was a panel reading "PRESS" which, when illuminated by a 7-1/2 w bulb, was the UCS. The conditioned (CS) and generalized (GS) words were projected onto the screen from E's room by an automatic slide projector. Key pressing responses (Kurcz, 1964) were detected by a Grass strain gauge rigidly mounted to S's chair desk, and were amplified and recorded by Grass low level dc amplifiers and Model 5 polygraph.

Procedure

Approximately two months prior to the beginning of the experiment, a "personality" questionnaire was administered to the Ss during their regularly scheduled class. The questionnaire contained 56 items from the

MMPI and nine new items related to the consumption of alcohol. Two Ss who in their responses to the critical items evidenced qualms against the taking of alcohol were automatically assigned to the control condition.

Upon entering the experimental room, Ss in the Placebo group were given a drink (Hetherington & Wray, 1964) consisting of 300 cc "7-Up," 30 cc concentrated lemon juice, and 5 cc peppermint extract. To these ingredients, reagent ethyl alcohol (cc = .35 by body weight in lbs.) was added for the Alcohol group. The E then reappeared and told them, essentially, that they had to learn to anticipate the onset of the "PRESS" light when the correct words appeared by depressing the strain gauge.

Ten trials of conditioned discrimination followed, during each of which the following eight words were presented in random order: male, buy, sea, plain, close, coarse, won, and weak. For each pair of Alcohol and Placebo Ss, a different subset of four of these words (CS+) was consistently reinforced. The remaining words (CS-) were never reinforced. The CS (and GS) words lasted 2.0 sec., the UCS lasted 0.5 sec., and the CS-UCS interval was 1.5 sec. The intertrial interval lasted about 2.5 sec.

In order to allow the alcohol to be further assimilated and to reduce rehearsal, all Ss then spent 20 min. performing a cancellation task. Thereafter, generalization was measured during experimental extinction. The four CS+ and CS- words were each presented twice and one synonym (man, purchase, ocean, simple, shut, rough, overcome, fragile), one antonym (female, sell, land, fan-cy, open, smooth, lost, strong) and one homonym (mail, by, see, plane, clothes, course, one, week) of each CS word were shown. The orders of presentation of the 40 words were random for each pair of Ss subject to the restriction that in each 10 word series, four CS and two each of the other three classes of words appeared. *Subjects*

Thirty-eight male undergraduates at the University of Florida served as Ss. Except for the restriction that all Ss in the Alcohol group had to be over 21 years of age and had to have responded appropriately to the critical items on the "personality" questionnaire, Ss were unsystematically assigned to the two groups. One S in the Placebo group misunderstood the instructions and his data were discarded.

RESULTS

Acquisition

No significant differences among the Alcohol and Placebo groups' means during the acquisition period

Table 1. Mean Generalization Indices

Group	Synonym	Antonym	Homonym
Alcohol (N = 19)	.02 ^B	.04 ^B	.66 ^A
Placebo (N = 18)	.50 ^{A,B}	.25 ^{A,B}	-.14

Note: Means having common superscripts are not significantly different ($p < .05$) as determined by Duncan Multiple Range Test.

were observed: the groups, respectively, made an average of 88.9% and 91.0% anticipatory responses to the CS+ and 8.7% and 8.6% to the CS- words. Performance in each group to the CS+ and CS- words appeared to stabilize after about four trials.

Generalization

Responses to CS- words and words related to them were not statistically different in any comparisons, and will not be described here. The responses to CS+ words by each group during the generalization test were significantly fewer than at the end of acquisition (Alcohol group $t=3.79$, $df=18$, $p < .01$; Placebo group $t=3.49$, $df=17$, $p < .01$). Because of this expected drop in performance, generalization was evaluated in terms of responsiveness to the CS words during the generalization test.

The mean generalization indices to the synonyms, antonyms and homonyms in each group is shown in Table 1. These were obtained by dividing the difference between number of responses to the GS+ and GS- words of each word class by the difference between the number of responses to CS+ and CS- during generalization, after correcting for differential opportunities to respond, e.g., $2 \times (\text{No. Rs to homonyms related to CS+} - \text{minus No. Rs to homonyms related to CS-}) / (\text{No. Rs to CS+} - \text{minus No. Rs to CS-})$. Analysis of variance of the data summarized in Table 1 revealed nonsignificant differences in overall generalization by the two groups ($F=0.00$, $df=1/35$) and in generalization to the three word classes ($F=0.40$, $df=2/70$) but a significant interaction between the presence of alcohol and the word class ($F=5.36$, $df=2/70$, $p < .001$). In fact, almost 63% of the variance in the data was due to the joint effects of alcohol and word class. As noted in Table 1, a Duncan range test revealed that Ss given alcohol generalize more to homonyms than

synonyms and that Ss given a placebo show the opposite tendency. It should also be noted that Ss given alcohol generalize more to homonyms than control Ss.

DISCUSSION

The data from the present experiment clearly show two crude, but opposed, generalization gradients. Normal adults given alcohol generalized more to homonyms than synonyms of the CS+ words, and matched control Ss showed the expected opposite trend. If, as White states, the action of alcohol "first touches the most recently evolved areas of the cerebral cortex which have a predominately inhibitory function" (p. 412) producing a general disinhibition, then there may be considerable merit to the position which describes a growth of phonotographic inhibition during the acquisition of linguistic habits.

It should be mentioned that, operationally, the present experiment was a classical conditioning one. The CR, UCR, and UCS, however, bear little resemblance to those conventionally employed in conditioning laboratories in this country. They closely mirror those currently used in the Soviet Union where this procedure is named voluntary instructed conditioning.

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Note

1. The authors wish to thank Miss Sharon Wright for her assistance in data collection. The use of The Psychophysiological Laboratory of W. B. Webb is appreciated. The research was supported in part by funds from The Graduate School, University of Florida.

Erratum

COPPOCK, H. W. GSR conditioning at a long CS-US interval mediated by S's counting behavior. *Psychon. Sci.*, 1966, 4, 155-156—The article should have included references to what appear to have been the first reports of overt verbal mediation of conditioning:

- Coppock, H. W., Claunch, E. S., Farwell, K. C., Hahn, I. N., & Hood, W. R. Effect of verbal responses during long CS-US interval on conditioning of GSRs. Paper read at Southwestern Psychological Association, Oklahoma City, 1954.
- Kimble, G. A. Classical conditioning and the problem of awareness. In C. W. Eriksen (Ed.), *Behavior and awareness*. Durham, N. C.: Duke University Press, 1962. Pp. 27-45.

Some indices of GSR activity in a long-delay conditioning paradigm¹

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Skin resistance was monitored while 32 Ss watched the sweep-second-hand of a Universal Timer. They had previously been told that each time the second-hand reached the 30 sec. mark they would receive a strong electric shock. The number and magnitude of anticipatory CR's given during the eight conditioning trials were positively correlated with basal conductance and nonspecific GSR activity, and negatively correlated with the recruitment and recovery times of the IICR to shock. Nonspecific GSR activity was positively correlated with both basal conductance and magnitude of GSR to shock.

Several investigators have reported that GSR conditioning is related to various indices of GSR activity. For example, Cadoret (1963) and Martin (1960) found that GSR conditioning was negatively correlated with basal skin resistance and positively correlated with nonspecific (spontaneous) GSR activity. Cadoret (1963) also found a significant positive correlation between magnitude of GSR to the UCS and conditioning. The present study reports on some similar relationships obtained in a form of long-delay conditioning paradigm. In addition to the indices mentioned above, several other response measures were obtained and related to conditioning.

Method

Eighteen male and 14 female students from a summer session course in introductory psychology served as Ss. Age ranged from 19 to 48 ($mdn = 22$) for the males, and from 18 to 50 ($mdn = 22$) for females.

The Ss were tested individually in a quiet room. After shock and GSR electrodes had been attached, the S was asked to sit quietly for the next 10 min. during which time basal skin resistance and nonspecific GSR activity were monitored. A Lafayette GSR Recorder and zinc-zinc sulphate finger electrodes were used for this purpose. The level of shock to be used in the experiment was then determined by gradually increasing the intensity of a 200 msec. shock (produced by a Psychological Instruments Model 1A Stimulator) until the S indicated that he was unwilling to accept anything stronger. His attention was then directed towards a Galab Universal Timer situated on a small table directly in front of him. After he had been told to watch the large sweep-second hand carefully, the timer was started and the second-hand allowed to complete one circuit (60 sec.). The S was then informed that each time the second-hand reached the 30 sec. mark, i.e., 30 sec. after the timer started and every 60 sec. thereafter, he would receive a shock similar to that previously determined to be his maximum. Eight trials of this

nature were given. This particular procedure was modified from one described by Zeaman & Smith (1965), and may be considered a special form of long-delay conditioning in which the UCS is presented at regular, predetermined intervals, and in which the S is informed of the CS-UCS relationship.

All resistance measures were converted to log conductance units ($\log \mu$ mhos) prior to statistical computation. The variables analyzed included the logarithms of the following: basal conductance (BC); number of nonspecific GSR's per minute in the basal period (NSP); magnitude of GSR to the last sample shock (UCR_0); recruitment time of UCR_0 , i.e., number of seconds from beginning of response to peak magnitude ($RCT - UCR_0$); recovery time of UCR_0 , i.e. number of seconds from peak magnitude to pre-stimulus level ($RCY - UCR_0$); magnitude of GSR to shock on the first (UCR_1) and eighth (UCR_8) conditioning trials; magnitude of the anticipatory conditioned response on the first (CR_1) and eighth (CR_8) conditioning trials; the mean number of seconds by which the CR preceded the shock during the eight conditioning trials (ANT); and the total number of CR's given (TOT-CR).

Results and Discussion²

During the first trial (no shock), most Ss showed a gradual, though slight decrease in conductance. Several response patterns were observed throughout the next eight (shock) trials. The two most frequent patterns were (a) no systematic change in conductance prior to the presentation of shock, followed by an UCR to the shock, and (b) a marked increase in conductance (CR) just prior to presentation of shock, followed by the response to the shock itself (cf. Hare, in press).

The matrix produced by intercorrelating the variables described above is presented in Table 1. These results indicate that conditioning, whether defined in terms of the number or magnitude of CR's elicited, is positively and significantly correlated with basal conductance and with the number of nonspecific GSR's per minute in the basal period. The findings reported by Cadoret (1963) and Martin (1960) are thus supported and extended to a long-delay conditioning procedure in which the UCS is presented at regular intervals. However, the additional finding by Cadoret (1963) that conditioning and magnitude of UCR were positively correlated was not supported.

An interesting finding was the relatively strong correlation (partial $r = .70$ when the effect of response magnitude is removed) between the recruitment and recovery times of UCR_0 . Perhaps more interesting were the consistent and generally significant negative

Table 1. Product Moment Correlations Between GSR Indices and Conditioning Measures (N=32)

Variables	BC	NSP	UCR ₀	RCT-UCR ₀	RCY-UCR ₀	UCR ₁	UCR ₈	CR ₁	CR ₈	ANT
NSP	.52**									
UCR ₀	.31	.52**								
RCT-UCR ₀	-.35*	-.50**	.14							
RCY-UCR ₀	-.40*	-.47**	.29	.71**						
UCR ₁	.23	.05	.61**	-.10	-.04					
UCR ₈	.04	.06	.33	-.27	-.08	.51**				
CR ₁	.63**	.51**	.14	-.18	-.37*	.19	.17			
CR ₈	.53**	.50**	.30	-.38*	-.33	.27	.04	.41*		
ANT	.32	.19	-.01	-.15	-.51**	-.13	-.20	.16	.33	
TOT-CR	.52**	.49**	-.01	-.36*	-.58**	-.06	-.15	.37*	.51**	.67**

* $p = .05$, ** $p = .01$, two-tailed test.

correlations between both the recruitment and recovery times of UCR₀ and the conditioning measures (magnitude and number of CR's elicited). Although not included in Table 1, negative correlations of the same order were also obtained between the conditioning measures and both the recruitment and recovery times of the UCR's throughout the experiment. This may mean that "good" conditioning is related to rapid autonomic discharge and quick recovery.

It should be noted that the effect of the instructions used was to produce, for some Ss, a CR on the first trial. Zeaman & Smith (1965) observed the same thing in cardiac conditioning studies and suggested that the effect represented a generalized response dependent upon prior experiences with shock and verbal warning of shock (p. 384). For some Ss in the present study, the instructions were apparently not sufficient to produce a CR on the first trial. Since these Ss tended to give relatively few CR's during the remainder of the experiment, it is possible that whatever prior experiences they may have had with verbal warnings of noxious stimuli were generally ineffective in developing conditioned emotional responses. The Ss who did give a CR on the first trial were also the ones who tended to give many, relatively large, CR's and who were characterized by high basal conductance, many nonspecific GSR's, rapid UCR recruitment and recovery, and by the elicitation of CR's well before the presentation of the UCS.

Some of the relationships between the indices of GSR activity are also of interest. The significant positive

correlation between basal conductance and nonspecific GSR activity is consistent with the recent suggestions that such a relationship should appear during periods of stress (Johnson, 1963; Miller & Shmavonian, 1965). Also in accord with Johnson's data on the relationship between nonspecific GSR's and GSR reactivity is the positive correlation between NSP and UCR₀. The lack of a significant correlation between NSP and the magnitude of the UCR's elicited during conditioning may reflect the fact that these latter responses were often superimposed upon, or came immediately after, an anticipatory response.

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Notes

- Supported by research grant APA - 139 to R. D. Hare from the National Research Council of Canada. The correlations were computed by the University Computing Center.
- None of the effects reported was related to sex or age of Ss.

The effects of performance feedback, social and monetary incentive upon human lever pressing rate¹

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Ss lever pressed on FR 10 for points. Points were given reinforcing properties by E's instruction. Results indicated no difference in variability or response rate for monetary or social reinforcement but large differences in variability for self competition. An incentive decrement effect hypothesis is discussed.

There is an increasing amount of evidence which is suggesting that the effect of incentive is that of reducing between-subject variability. Data from several studies, particularly child studies, lead one to consider the possibility that the incentive does not reduce variability only by increasing the rate of low responders but also by decreasing the rate of high responders. Terrell (1958), for example, found that in a group of intrinsically motivated children, discrimination learning was best under conditions of performance feedback and poorest under conditions of added incentive. These results were directly opposed to an earlier study (Terrell & Kennedy, 1957) in which lower socio-economic class children, and presumably less highly self-motivated, were used.

Other data from child studies may also be interpreted in terms of an incentive decrement effect. Stevenson and Hoving (1964), for example, found that nursery school children made more correct responses in a probability matching situation under low incentive (a washer) than under high incentive (a nickel). Miller & Estes (1961) report similar results—fewer errors with performance feedback relative to monetary reward.

Although discrimination learning is not the best experimental situation for determining incentive decrement effects because of the uncontrollable effects different incentive conditions may have upon interfering responses, the above results are in agreement with findings in lever pulling situations. Ryan & Moffitt (1965) found that faster speeds were obtained when children were lever pulling for a low incentive (a piece of string) than for a high incentive (a ten cent toy). This was in general agreement with Bruning's (1964) finding of a slight (non-significant) decrement in children's lever pulling speed for a large incentive (five pieces of candy) relative to the speed obtained for a smaller incentive (one piece of candy).

The present study compared the effectiveness of several quite different incentive conditions with a performance feedback control in maintaining simple lever pressing behavior.

Method

Ss were seated in a ventilated sound resistant cubicle about 4.5 ft. by 5 ft. in size. The cubicle contained a standard 19 in. by 21 in. table model relay rack on which a light, an electric impulse counter and a Stromberg-Carlson cam key (No. 171D) were mounted.

The experimental session consisted of 45, 20-second periods indicated by light onset on the S's panel, during which time the S could accumulate points shown on his counter in a ratio of 1 point for every 10 lever presses (FR 10). Stimulus presentations, reinforcement points, recording of lever pressing responses, etc., were accomplished by means of standard programming and recording apparatus.

Once seated in front of the response panel, the S heard the instructions over an intercom system. All Ss were informed that the study was concerned with "motor activity" and that they could accumulate points as shown on their counters if they pushed the lever rapidly whenever their panel light was on and that the faster they manipulated the lever the more points they would receive.

Five groups of 6 male students registered in the introductory psychology course at Dalhousie University constituted the sample. Each S, regardless of his assigned experimental group, received identical instructions save for the last sentence, which established the reinforcing significance of the accumulated points. The conditions were as follows:

Self competition (SeC) — "Try to accumulate as many points as possible."

Class norm (CN) — "Most males in your class obtain about 450 points or about 10 per trial; try to accumulate as many points as possible."

Social competition (SoC) — "You are competing against 5 other persons;..."

Social competition for monetary reward (SCM) —

Table 1. Average number of responses per second and range of response rates for the last ten trials in each condition

Condition	Mean No. of Responses Per Second	Range Mean No. of Responses Per Second	
		Fastest S	Slowest S
SeC	5.8	9.4	2.4
CN	6.8	7.8	4.1
SoC	6.4	7.8	5.0
SCM	6.2	7.2	5.0
M	6.1	7.2	4.2

"You are competing against 5 other persons for \$2.50;..."

Monetary reward (M)—"You will receive 1¢ for every 5 points you accumulate;..."

Results

Table 1 shows the average number of responses per second and the range (i.e., fastest and slowest subject means) during the last ten trials for each condition. As indicated by the range, there is considerable variability in the SeC group relative to the other conditions.

Considerably less variability may be observed in the last ten trials of conditions CN, SoC, SCM and M. A Cochran's C test for homogeneity of variance (Winer, 1962) indicated a significant departure from homogeneity between the five groups ($C = .625, p < .01$). A Cochran's test on groups CN, SoC, SCM and M indicated no significant difference in variability ($C = .281, p < .05$) which indicates that the self competition condition results in a population which has a markedly different variance from the social or monetary conditions.

The average number of responses per second over the course of the experimental session for each group is shown in Fig. 1. The SeC group was divided in half so that the mean for the three fastest responders and the three slowest responders are plotted separately. This arbitrary separation shows quite well the striking difference between fast and slow responders in the performance feedback (SeC) condition.

The four incentive plus performance feedback conditions all have similar response curves. An analysis of variance on the last 10 trial data for these four groups indicated no significant differences ($F < 1.00$).

Discussion

The results indicate that social competition is as effective as a small monetary reward in terms of

maintaining lever pressing and yielding a homogeneous population variance. Of particular interest is the marked heterogeneity observed in the self competition condition where some Ss demonstrate very low response rates (e.g., 2.4 responses per second) while others evoke exceedingly high response rates (e.g., 9.4 responses per second) which, for some Ss, show little indication of asymptote after 45 trials. It is quite likely that, for some Ss, self competition may be a natural concomitant of performance feedback situations and a very effective motivator and that the effect of additional motivating contingencies (i.e., money or social competition) may be that of actually inhibiting maximum response rate. For other Ss less responsive to the self competitive situation, social or monetary reinforcers may be necessary to maintain behavior.

Finally, although some authors have attempted to explain unexpected results in terms of a frustration or a similar state theory, a consideration of Fig. 1 suggests hypotheses based upon an incentive decrement effect notion which might explain the inconsistencies in the literature. The often reported finding of performance feedback being superior, in terms of some performance measure, to performance feedback plus incentive is accounted for by the decremental effect of incentive upon intrinsically motivated subjects. The many "no difference" results would be obtained if a sample of highly and poorly motivated Ss were used and their response rates averaged. If poorly motivated Ss were used (e.g., lower class children), incentive effects would be obtained.

The hypotheses derived from these preliminary data required within-subject designs for adequate test. Studies of this nature are in progress.

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Note

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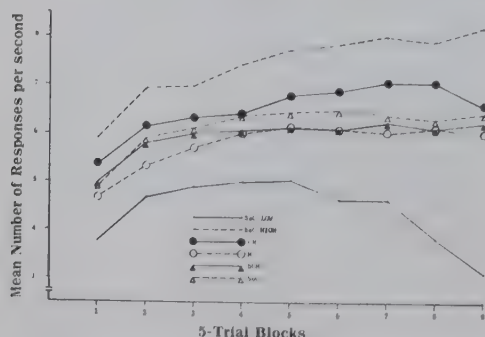


Fig. 1. Average number of responses per second for all groups as a function of 9 blocks of 5 trials per block. The three fastest and the three slowest Ss in group SeC are plotted separately.

Some cross-cultural data on probability learning¹

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Extended training in a probability learning task was given to 17 Ss from two non-western cultures. Ss came from Moscow University, USSR and Cuttington, Liberia, a small rural African town. Long-term probability matching was obtained in both groups. However, the trial-to-trial changes in response proportions varied markedly between groups; Liberian Ss tended to follow the reinforcing events, while responses by the Russian Ss depended more heavily on their own preceding responses. Some negative recency effect was obtained for both groups. This effect decreased somewhat over trials, but was still present at the termination of training.

A probability learning task was run for an extended number of short sessions on two groups of Ss from non-Western cultures. Most of the previous studies have used Ss from the West European-American cultural milieu and the typical results for group data are probability matching (see Estes, 1964) and negative recency (see Jarvik, 1951; Nicks, 1959). Probability matching occurs when the mean learning curve approaches the probability of the occurrence of the predicted event, and negative recency occurs when the probability of predicting an event decreases as the runs of that event increase.

METHOD

Subjects

The first group consisted of seven college students from Moscow State University. The second group was 16 schoolboys from small villages in Liberia. They were 10 to 14 years old and had one to two years of formal education.

Procedure

A sequence of reinforcing events was generated separately for each S using a method of unrestricted randomization with the probability of event "1" equal to .667 and the probability of event "2" equal to .333. There were 100 trials which took about 6 sec. each in a session. Sessions ordinarily followed each other by at least a 1-day interval, although on occasion several days intervened between sessions. Due to language difficulties and time schedules the following procedural differences occurred: (1) The Russian group responded verbally to E's signal of tapping a pencil on the table, and then E read aloud the appropriate event. Twenty sessions were run. (2) The Liberian group predicted whether one or two bottle tops would be shown, and E produced one or two of them. Five sessions were run for 10 Ss while additional 6 Ss completed two sessions. The data from all Ss are used where appropriate.

RESULTS

General Findings

Figure 1 shows the mean probability of choosing the more frequently reinforced alternative in 50-trial

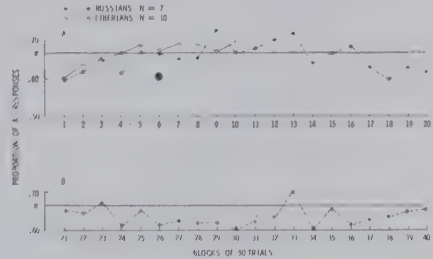


Fig. 1. Learning curves

blocks. For the 500 trials they have in common, the curves of the two groups are very much alike. With more extended trials, the Russian group's curve is relatively stable just below the event probability value. The terminal mean response proportions in Table 1 indicate that none of the Ss are maximizing (consistently choosing the more frequently reinforced event) and that several Ss are very close to the matching level.

Recency analysis

The recency curves plotted in Fig. 2 a-b and Fig. 3 a-b show the proportion of predicting that an event will occur as a function of the length of the immediately preceding run of that particular event. The analysis has been divided into three blocks of trials in order to investigate possible changes in the shapes of the curves as a function of training. Although the data manifest some variability, certain trends may be discerned. Most of the curves decrease as the length of the preceding runs becomes longer. There are, however, some portions which increase with increasing runs. There is also a tendency for the curves to reach and maintain a higher level as the amount of training increases.

The recency curves of the Liberian group differ from those of the Russian group in two distinct ways. First,

Table 1. Terminal Proportions of A_j Choices by Subjects

Subject	Group	
	Russian ¹	Liberian ²
1	.599	.768
2	.557	.680
3	.673	.796
4	.671	.572
5	.644	.800
6	.667	.512
7	.698	.668
8	—	.720
9	—	.608
10	—	.740

¹ Trials 1001-2000

² Trials 376-500

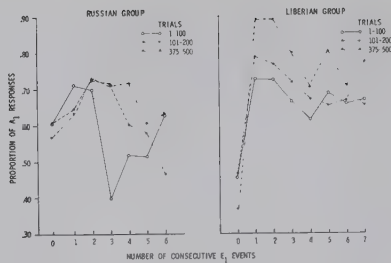


Fig. 2. Recency curves for the most frequent event

the Liberians show a strong tendency to switch their predictions following a change in the event, while the Russians do not. Secondly, the Liberian curves for the A_2 response following 1, 2, and 3 preceding occurrences of E_2 are at a much higher level than the overall level of making the A_2 response, while the Russian curves remain close to the overall level of choosing A_2 .

Sequential analysis

The proportion of responses conditional on the previous response and the previous event are presented in Table 2 for the final blocks of trials. The Liberian group shows a tendency to predict the event which occurred on the previous trial, but with relatively little dependence on the previous response. The Russian

Table 2. Conditional Proportions for a Terminal Block of Trials

Event		Liberians ¹	Russians ²
$A_{1,n+1}$	$E_{1,n}$	.84	.67
$A_{1,n+1}$	$E_{2,n}$	.35	.62
$A_{1,n+1}$	$A_{1,n}$	.68	.68
$A_{1,n+1}$	$A_{2,n}$	.71	.56

1 Trials 376-500

2 Trials 1501-2000

group shows a different pattern with little dependence on the previous event, but a slight tendency to repeat the previous response.

DISCUSSION

Although both groups showed evidence of a negative recency effect, none of the curves conform to the classic form of the negative recency curve as found by Jarvik (1951) and Nicks (1959). Some changes toward less negative recency occur during the training period but even in the final block of trials the curves are not monotonically increasing.

In view of the unavoidable multiple confoundings inherent in our casual data gathering procedures, we can only indicate what we view as the more reliable conclusions suggested by the data. First, there is evidence of long term probability matching by both groups. Second, there is an unusually strong tendency for the Liberian group to predict the event which occurred on the previous trial. Third, there is the presence of negative recency or "gambler's fallacy" in two non-American cultures.

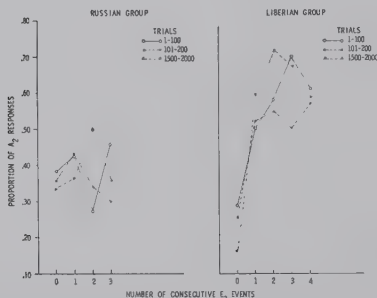


Fig. 3. Recency curves for the least frequent event

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Note

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Reaction time to electrocutaneous onset and offset stimulation

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Reaction times were obtained from two Ss to the onset (beginning) and offset (cessation) of 70 cps AC electrocutaneous stimuli of three sensation levels: low, medium and high. The results indicated that onset was faster than offset RTs at all three intensity levels.

In 1915, Woodrow found that reaction times (RTs) were faster to the onset of an alternating current than to the offset of the current. He reported that, following the offset of his stimuli, sensations of "after-tingling" occurred. He suggested that the latter phenomenon may have detracted from the detection of the offset of the stimulus, which would have resulted in longer RTs.

Woodrow's work was, by his own declaration, only of a cursory and crude nature. Because of the importance of understanding the basic nature of an electrocutaneous stimulation in the development of an electrocutaneous communication code, a project with which the authors are currently concerned (cf., Foulke, 1964), it was decided to reinvestigate the onset-offset problem confronted by Woodrow. In addition to the use of electronics equipment which permitted vastly improved control of the stimulus than that available to Woodrow in 1915, the present study differed from Woodrow's in that three stimulus intensities, ranging from very weak to strong, were used.

Method

Subjects were two male graduate students who were well practiced (three hr.—over 450 reactions) in reacting to electrocutaneous stimuli like those used in the present study.

A Hewlett-Packard audio oscillator (model 201CR) provided a 70 cps alternating signal. The output of the oscillator was channeled through an attenuator (Daven Company, type 7717) to a Grayson-Stadler model 829D electronic switch. The output of the electronic switch was coupled to a 75 watt McIntosh audio amplifier. The amplifier impedance was matched to S's impedance by a United Transformer, type L5-12. A 100K-ohm potentiometer (General Radio type 978-R) and a 100K-ohm fixed resistor were connected in series with S in order to limit changes in stimulus current due to fluctuations in S's resistance. A 100K-ohm precision resistor was also connected in series with S and stimulus current was determined by measuring the voltage drop across this resistor with a Ballantine AC voltmeter (model 300E). S's active electrode was a circular stainless steel disc (5/8 in. diameter). The inactive electrode was a 3-1/2 by 2-1/2 in. stainless steel plate which covered the breadth of S's palm.

Stimulus intensity was adjusted by reference to the voltmeter. Stimulus foreperiods were controlled by means of a Hunter model 100B decade interval timer which was connected to the external control circuit of the electronic switch. Reaction times were measured with a Hunter Klockounter.

A single-pole, double-throw toggle switch, connected between the Hunter timer and the electronic switch, permitted two modes of stimulus presentation. With the toggle switch in one position, the signal came on when the Hunter timer was first activated and stayed on until the end of the interval set on the timer, at which time the electronic switch was triggered and the signal turned off. S reacted, under these conditions, to the offset of the signal. With the toggle switch in its other position, the electronic switch turned the signal on at the end of the interval set on the Hunter timer. In this case S reacted to the onset of the signal.

Ss were seated in an Industrial Acoustics Company model 400 sound-deadened booth. To obtain a reaction, E set the foreperiod (which was varied randomly from 1.5 to 4.0 sec. in steps of 0.1 sec. to prevent synchronization of responses) on the Hunter timer and threw the toggle switch to one of the positions described above. Then he signalled S that all was ready. S placed the first phalange of his left index finger on the active electrode and rested his left palm on the inactive electrode. He produced his own stimulus by depressing a footswitch. The latter closed the Hunter timer circuit, thus beginning the foreperiod. At the end of the foreperiod, the timer triggered the electronic switch and, at the same time, closed the Klockounter circuit. In series with the Klockounter circuit was S's response (telegraph) key. S held the key closed until he felt the reaction signal. He then released the key which broke the Klockounter circuit. When the Klockounter circuit was broken, the time from the initiation of the stimulus until the circuit was broken was registered on the Klockounter. This time was recorded by E as S's reaction time.

Three intensities were used. For S S.Z., these were 440, 560 and 700 μ A, and for S H.T., they were 480, 570 and 720 μ A. There were six experimental conditions (onset and offset stimuli at three intensities). During each session 25 RTs (taken in blocks of five per condition) were obtained for each stimulus combination. Hence, 150 RTs were taken each experimental session. There were two sessions, giving a total of 50 RTs per condition. Stimulus combinations were counterbalanced to preclude order effects.

Table 1. Means and Standard Deviations of the Reaction Times for Two Subjects to the Onset and Offset of A. C. Electrocutaneous Stimuli at Three Levels of Intensity (see text for intensity in μ A).

Ss	Score	Low		Intensity Medium		High	
		Onset	Offset	Onset	Offset	Onset	Offset
S.Z.	Mean	214	352	171	237	162	227
	S.D.	56	133	25	33	14	23
H.T.	Mean	347	476	257	297	214	254
	S.D.	63	103	27	47	29	18

Results

The median RT for each block of five trials was computed, and the mean of these 10 medians for each mode by intensity combination for each S was obtained. Table 1 presents these data, along with the corresponding standard deviations. Figure 1 presents these data graphically with mean RT (in msec.) on the ordinate and intensity (I) on the abscissa. It is apparent from the figure that offset RTs are in all cases longer than onset RTs.

The Wilcoxon matched-pairs signed ranks test (Siegel, 1956, pp. 75-83) was performed with the 10 median onset and offset RTs obtained under each intensity for each S, and confirmed the differences indicated in Fig. 1 (in all cases $p < 0.01$). The intensity variable was tested for significance using the Friedman two-way analysis of variance performed on the mean data presented in Table 1. This analysis indicated that the changes in both onset and offset RTs, as a function of intensity, were significant ($p < 0.005$). Both onset and offset RTs decrease as intensity increases. The difference between the offset and onset RTs is greatest

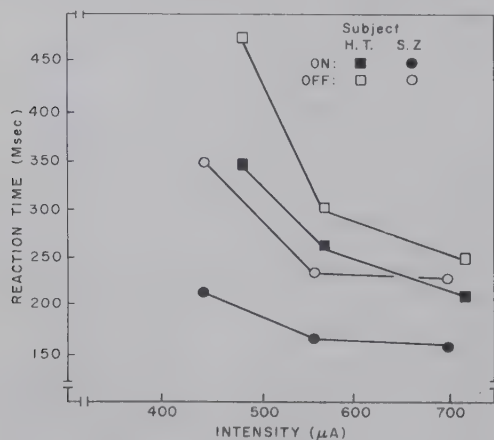


Fig. 1. Mean RTs for two Ss to onset and offset of electrocutaneous stimuli plotted against stimulus intensity in microamperes (μ A).

at the lowest intensity, but does not appear to change much between the middle and strongest intensity. Visual inspection suggests that the rate of increase in RT as the intensity is decreased is greater for offset than for onset RTs.

Discussion

These results confirm those of Woodrow (1915) in demonstrating that the RT to electrocutaneous stimulation is faster to the onset than to the cessation of stimulation. Woodrow attributed this to "after-tingling" set up in the fingers by his stimuli, which thus acted as a mask for the stimulus offset. In the present study, no obvious "after-tingling" occurred. Ss reported that there was a tendency for the stimulus to "adapt-out" (i.e., fading of sensation) with continued application. This was most obvious with the weakest intensity. Thus, the subjective intensity of the stimulus was less at the offset than at the onset—a fact indexed by the RT data (both the subjective reports and RT findings were subsequently replicated with a third S, the second author).

Data of others suggest that electrical stimuli stimulate peripheral nerves rather than (or in addition to) specialized receptor endings (cf., Hawkes, 1960, p. 53). It is known that such nerves show adaptation to constant current stimuli (Adrian, 1928, pp. 68-69). By adaptation is meant a gradual decrease in the total number of neural impulses propagated by a peripheral nerve with continued constant current stimulation. The results of the present study suggest that with the onset of the constant current, alternating electrical stimulus, an initial "burst" of neural impulses produced a strong signal of the change in neural state, such being demonstrated by the speed of the onset reaction. Due to adaptation effects occurring in the nerve with the continued application of the stimulus, a reduced nerve input remained to be modulated with stimulus offset, and such was reflected by the offset RTs being longer than the corresponding onset RTs. Further tests of this adaptation hypothesis are underway.

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Probability learning of response patterns¹

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A 4-light, 4-key probability learning task was altered by having *S* predict which 2 of the 4 lights would occur each trial. The question is whether *S*'s habit hierarchy is best represented as composed of 4 single-key habits from which two responses are successively selected, or composed of 6 unitary response-pair habits from which one pair is selected per trial. The data favor the latter representation, since the asymptotic proportions of response pairs matched the corresponding light-pair probabilities.

This experiment tries to clarify a conceptual puzzle that arises from a slight alteration of the standard probability learning situation. In the standard situation, on each trial *S* predicts and then is shown one of *n* events. As viewed by stochastic models (Estes, 1964; Luce, 1959), *S*'s repertoire in this situation is represented as consisting of *n* response alternatives (where A_i = prediction of event E_i) and their associated strengths or probabilities. Further it is assumed that the *n* response probabilities are changed each trial in a manner depending upon the "reinforcing" event. Under suitable circumstances, the model and the data (Estes, 1964) agree that response probabilities will asymptotically match the corresponding event probabilities.

Let us now alter this standard situation by collapsing two trials into one. In our experiment, there were 4 event lights and 4 response keys. But here, two of the 4 lights occur on each trial and *S*'s task is to predict the two lights that will occur. There are 6 pairs of lights and *E* presents pair i_j with probability π_{ij} independent of *S*'s responses.

The puzzle is how best to identify the response alternatives to which any stochastic model is to be applied in this situation. Two opposing identifications of *S*'s "habit profile" are apparent; we shall call these the "singlet" and "doublet" identifications, respectively. According to the singlet approach, we identify only the four single-key responses. The reinforcing events are viewed as changing the strengths (probabilities) of these four responses, and it is supposed that *S* predicts a pair of events by two successive selections from this 4-habit hierarchy (e.g., according to Luce's (1959) ranking rule). By this view, a single response comes to occur at a frequency dependent upon the marginal probability with which its corresponding light has occurred in the paired reinforcing events.

According to the alternative "doublet" identification, we completely segregate the 6 response pairs, treating them as 6 distinct, "unitary" responses with no transfer of strength between overlapping patterns. Thus, reinforcing event E_{ij} increases only the probability of response pair A_{ij} and not other pairs involving A_i or A_j . According to this view, we may expect the asymptotic probability of response doublet A_{ij} to match π_{ij} , the cor-

responding doublet-event probability. Contrariwise, by the singlet view, such doublet-event probability matching would be expected only for special reinforcement schedules (e.g., uniform π_{ij} 's). Our experiment was designed to decide between these two identifications.

Method

The *Ss* were 30 students from an Introductory Psychology course; they were tested individually. They comprised two groups of 15 *Ss* each; the groups differed in the six π_{ij} values, which are listed in rows 1 and 4 of Table 1. Each *S* had a different sequence of 384 trials, with the π_{ij} proportions realized exactly in each block of 48 trials. The apparatus was a modified Humphreys board with a white warning light, a row of 4 red event lights, and below a corresponding row of 4 push buttons. *E* controlled the light pair presented each trial by a 6-position rotary switch which was rotated silently between trials. Another rotary switch allowed *E* to counterbalance across *Ss* which keys and lights served as A_1E_1 , A_2E_2 , etc.

Because the instructions are probably quite important, they follow verbatim:

"This is an experiment concerned with how people develop expectations about events in their environment. Before you is a board with a white light at the top, four red lights in the middle, and four push-buttons, one underneath each of the red lights. The experiment will be divided into a series of separate trials. Each trial commences when the white light at the top comes on. Three seconds later two of the four red bulbs will come on for two seconds, and the trial will end. Your job is to predict as best you can which two bulbs will light at the end of the trial. You are to indicate your predictions by briefly pushing the button under each of the two red bulbs which you expect will light up at the end of the trial. After the white light comes on, you have exactly three seconds in which to make your two predictions, so you will have to make your decisions quickly. You can see whether your predictions are correct by comparing them with the two bulbs that light at the end of the trial. You should strive to be correct as frequently as possible. In the first few trials you will just be guessing, but as you learn more about what to expect the accuracy of your predictions will improve somewhat. Remember that you are to make two predictions (push two different buttons) each trial after the white light and before the red lights. Do not push the two buttons simultaneously; use the index finger of your preferred hand to push the button of your first choice, release it, then push the button of your second choice."

Results

Although the order of occurrences of the two responses each trial was recorded, analysis revealed no systematic trends in these data. Typically Ss used a "left-to-right" order in pushing the two buttons, independent of the reinforcement probabilities. Accordingly, the order will be ignored in discussing the response pair data.

The results most relevant to our question are the asymptotic proportions of the 6 response pairs. These appear rounded to two decimals in rows 2 and 5 of Table 1; they are group averages taken from the final 48 trials, by which time response proportions appeared stable. The observed proportions match the event proportions (the π_{ij} 's) with remarkable accuracy. Indeed, the overall match is closer than that often obtained in the standard single-response, single-event situation. Inspection of individual Ss' proportions revealed no glaring discrepancies from the group averages in Table 1.

To gauge the decisiveness of the results, one particular singlet model was developed. Let Q_i represent the operator corresponding to single event E_i for the standard model, and let Q_{ij} be the operator corresponding to the double event E_{ij} . Define Q_{ij} as $.5(Q_i Q_j + Q_j Q_i)$. Letting $p_{k,n}$ be the probability that A_k is the first response on trial n , the equation for the Q_{ij} operator is

$$Q_{ij} p_{k,n} = (1 - \theta)^2 p_{k,n} + d_{ijk} \theta (1 - .5 \theta),$$

where d_{ijk} equals 1 if $k=i$ or j , and equals 0 otherwise. Such operators produce asymptotes of $p_k = .5\pi_k$, where π_k is the marginal probability that light k occurs. Using Luce's ranking rule (pick most preferred, eliminate it, choose next preferred) for predicting response pairs, the doublet predictions in rows 3 and 6 of Table 1 are then obtained. These predictions are obviously poor. Generally, the singlet predictions err by being more uniform (equiprobable) than are the observed proportions. An informative discrepancy is the A_{23} doublet for Group A. Event E_{23} never occurs and Ss learn this, whereas the singlet model expects some A_{23} responding because it views the single responses A_2 and A_3 as separately strong.

Asymptotic response-pair proportions conditional upon the preceding response-pair and reinforcement were inspected but will not be reported. Too few ob-

servations are spread over the $6^2 = 216$ proportions to provide any reliable conclusions.

Discussion

The double-response identifications were clearly appropriate in this experiment; that is, the response pairs came to function as unitary patterns. It is not possible to determine from these data whether a shift from component to patterned responding occurred over the course of learning; possibly a more sensitive experiment could decide this issue.

The patterned responding found here raises questions about experimental limits, whether an experimental continuum can be contrived for moving S from component to patterned responding. The temporal placement of the two "reinforcing" lights with respect to the two predictive responses would appear to be critical. Our situation, which produced patterned responding, gave both lights together after the two responses, and the two responses were not distinguished. But suppose the two targets were separately labelled (say A and B), and the trial sequence were "predict A, then predict B; show target A, then target B". Or a slight variant: "predict A, show target A; predict B, show target B". Each of these variants would probably move S somewhat in the direction of "singlet" responding since they approximate more closely a simple convolution of the standard situation. It seems likely too that S's instructions and the reinforcement conditions (e.g., whether the locations of the A and B targets are dependent or independent) would be important factors biasing S towards singlet or doublet responding. Readers familiar with statistical learning theory will notice the functional parallel between this issue (singlet vs. doublet response identifications) and one characterizing different models of discrimination learning (component vs. pattern stimulus identifications). The two problems are indeed analogous.

The experimental alteration tried here suggests a general format of the Humphreys game: on each trial S is to choose K out of N lights, trying to hit as many as he can of T target lights that will appear (where $N > K > T$). Alternatively S might rank order the N alternatives each trial. Such methods would obtain more information about S's habit hierarchy each trial than does the standard single-response method. Unfortunately, little evidence is presently available to even suggest the general outlines of the stochastic models required to deal with the data from such experiments. Previous research on probability learning has dealt exclusively with the $K = T = 1$ case.

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Note

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Table 1. Event proportions, observed response-pair proportions, and singlet predictions for the two groups of Ss. Response proportions are group averages obtained from the final 48 trials. All proportions are rounded to two decimals.

Group	Event prob., π_{ij}	Response Pairs					
		12	13	14	23	24	34
Group A	Obsd. prob., π_{ij}	.29	.29	.08	0	.08	.25
	Obsd. prob., p_{ij}	.29	.29	.05	0	.10	.26
	Singlet prediction	.17	.26	.19	.13	.10	.15
Group B	Event prob., π_{ij}	.33	.08	.08	.08	.33	.08
	Obsd. prob., p_{ij}	.33	.07	.08	.09	.36	.07
	Singlet prediction	.27	.08	.17	.13	.27	.08

Serial CVC learning with varied $\underline{m}'$ but equal $\underline{a}$ values¹

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Two investigations were conducted on 140 Ss from widely-separated college populations to test the hypothesis that speed of acquisition in the serial verbal learning of consonant-vowel-consonant (CVC) material is a positive function of scaled meaningfulness ($\underline{m}'$), even when the association values ($\underline{a}$) of the lists are held constant. Appropriate norms for the relevant scale values were drawn independently from the two geographical regions. Contrary to popular belief that $\underline{m}'$ and $\underline{a}$ are either identical or proportional measures, both experiments were consistent with the hypothesis as derived from Noble's curvilinear principle. It is thus a replicable fact that the memorization of CVCs selected from the high ends of the two scales depends more upon $\underline{m}'$ than upon $\underline{a}$.

The history of research on the roles of meaningfulness, association value, and related variables in verbal learning is available elsewhere (Noble, 1952; Noble, 1961a; Noble, 1963; Underwood & Schulz, 1960) so it need not be summarized here. Suffice it to say that, although the problem of controlling sources of variance among verbal stimuli began with Ebbinghaus, it is still very much with us. The task of discovering the basic laws of verbal learning and performance requires careful analysis of the quantitative properties of the independent variables. Yet there are those who disregard the operational distinctions between $\underline{m}'$ -value (standard-score transformation of 5-category comparative judgments of Ss' number of associations to a given CVC) and $\underline{a}$ -value (relative frequency of Ss who report at least one association to the CVC). In spite of two independent studies which demonstrated that $\underline{a}$ and $\underline{m}'$ are neither equivalent by definition nor linear in regression (Noble, Stockwell, & Pryer, 1957; Noble, 1961a), there still exists a common opinion among psychologists that these two concepts are interchangeable. Nor is the misunderstanding confined to introductory textbooks. It has even clouded the writings of research specialists (Underwood & Schulz, 1960; Archer, 1961), as one of us has occasionally remarked (Noble, 1961a; Noble, 1961b; Noble, 1962; Noble, 1963). Indeed, the senior author has consistently argued for the superiority of meaningfulness scales over association-value indices, and has hypothesized that learning scores depend more on $\underline{m}'$ than on $\underline{a}$.

History aside, perhaps the old-fashioned *experimentum crucis* approach will clear the air. Specifically, from the empirical fact that $\underline{a}$ is a sigmoidal function of $\underline{m}'$, which for the full range of CVCs is essentially flat in the upper register (cf. Noble, 1961a, p. 510), it follows that a certain range of $\underline{m}'$ -values may be

selected whose $\underline{a}$ -values are approximately equal. By judiciously varying $\underline{m}'$ for different groups while holding $\underline{a}$ constant, we reasoned that a critical test of the following hypothesis should be possible; viz., that rate of acquisition in serial CVC learning is a positive function of $\underline{m}'$ even when $\underline{a}$, its normal correlate, is experimentally neutralized. Two experiments were designed to determine the truth or falsity of this hypothesis.

Method

In Experiment I 50 University of Montana Ss were assigned equally and without bias to 5 lists of 10 CVCs each. Based on the Montana norms (Noble, 1961a), the mean $\underline{m}'$ -values were 3.31, 3.59, 3.84, 4.09, and 4.37; mean $\underline{a}$ =1.00. Item order was random except that no letter was used more than 5 times in any list, no letter appeared more than 3 times in adjacent items in any list, no adjacent items formed a familiar phrase or hyphenated word, and each item occurred once in every serial position. Following standard instructions pertaining to the pronunciation-anticipation technique, all Ss received 20 trials by the correction method. Trial 1 was for familiarization; Ss began anticipating on Trial 2. The apparatus was a Patterson memory drum which exposed each item for 1 sec., followed by a shutter closure of 1 sec. The intertrial interval was 5 sec., measured between offset of the last item to onset of the cue symbol.

In Experiment II 90 University of Georgia Ss were assigned equally and without bias to 3 lists of 10 CVCs each. Based upon unpublished Georgia norms drawn from 200 different Ss, the mean $\underline{m}'$ -values were 2.33, 2.79, and 3.36; mean $\underline{a}$ = .997. All other procedural details of Experiment II were exactly the same as Experiment I, except that a Stowe memory drum was used.

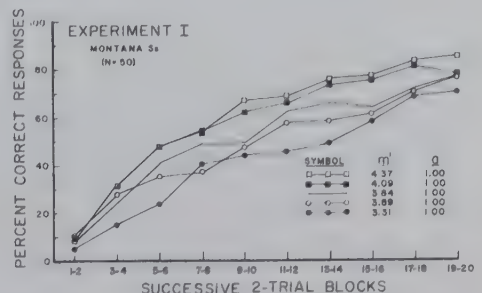


Fig. 1. Acquisition curves for 5 lists of CVCs in Exp. I as a function of $\underline{m}'$. Each curve contains 10 Ss.

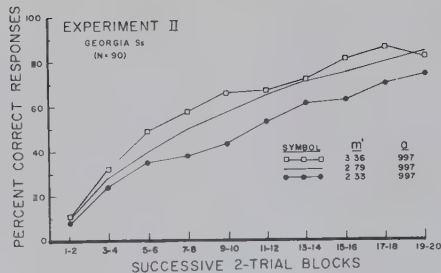


Fig. 2. Acquisition curves for 3 lists of CVCs in Exp. II as a function of m' . Each curve contains 30 Ss.

Results

The data of Experiment I are presented in Fig. 1, where it can be seen that there is a clear rank-order agreement between rate of acquisition and m' -value for the 5 groups. The data of Experiment II are shown in Fig. 2, confirming the first study for 3 groups drawn from a geographically disparate population with different norms.

Considering the preexperimental hypothesis under evaluation and the metrical nature of the data in Experiments I and II, an appropriate statistical test is that of Jonckheere (1954). In the usual analysis-of-variance test for 3 or more groups, the F-ratio is not sensitive to the rank order of the group means. Furthermore, the unit of measurement may not be constant throughout the scale of the dependent variable. What is needed in the present study is a distribution-free or nonparametric comparison of (1) our positive hypothesis that various levels of m' will produce a particular ordering of the groups' frequency distributions for total correct responses with (2) the null hypothesis that such distributions will differ only randomly; i.e., that the several groups within each experiment might have been drawn from the same population as far as their cumulative acquisition scores are concerned.

Applying Jonckheere's Test to the data of Experiment I, we computed an S-statistic of 322, which is sufficient to reject the null hypothesis ($p < .01$). Similarly, the data of Experiment II yielded an S-statistic of 980, which is also significant ($p < .01$). The rank-difference correlation coefficient (ρ) between predicted and obtained performances was 1.00 in both experiments.

Discussion

It is evident from the graphical analyses (Figs. 1 & 2) and the two statistical tests that speed of acquisition in the serial verbal learning of CVC material is a positive function of m' . With respect to control variables,

we held constant the mean a -value of all lists in each experiment, so association value cannot be used in lieu of scaled meaningfulness to forecast the learnability of CVCs within this range. The suggestion has also been made (Underwood & Schulz, 1960) that rated pronounciability may be a more fundamental variable than m' , but it is now known that pronounciability can statistically be removed from certain interrelationships by partial correlation methods without affecting the m' contribution (Noble, 1962; Noble, 1963). Just to make sure, we drew independent samples of 100 Ss each from the Montana and Georgia populations and administered the pronounciability schedule for 100 full-range CVCs according to the Underwood-Schulz procedure (1960, pp. 23-24). Despite high intergroup reliability coefficients ($\geq .98$), mean rated pronounciability for the relevant items correlated less strongly with the ranked acquisition data than did m' . For Experiment I, $\rho = -.90$; for Experiment II, $\rho = -.50$. Since higher proportions of variance were accounted for by m' in all cases, we conclude that neither pronounciability nor association value is more effective in predicting ease of memorization than is scaled meaningfulness. Our hypothesis is sustained.

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Note

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Visual figural after-effects and field dependence

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Visual figural after-effects are shown to be related to measures of field dependence (as assessed by the Rod and Frame Test). Field independent Ss exhibited such after-effects while field dependent Ss failed to demonstrate these effects on a specific perceptual task. Since measures of field dependence have been previously found to relate to broader personality and behavior variables, the present evidence suggests then that such complex behavior variables might in turn be related to elemental cortical traces of a type involved in the generation of figural after-effects.

Although Gibson's (1933) first systematic accounts of figural after-effects generated increasing research interest in this aspect of the perceptual process, up to date, the pertinent literature makes only very scant reference to the presence of individual differences. To be sure, Wertheimer (1954) reports that schizophrenics show weaker after-effects than do normal Ss, while Eysenck (1955), utilizing kinesthetic after-effects, demonstrates more pronounced after-effects in hysterics. However, no concerted attempts have as yet been made to relate systematically individual differences found within normal S groups to specific and circumscribed variables, though an often wide range of such individual differences are seen in the results of a great many studies. Ss, for example, under identical test conditions differ not only with regard to the magnitude of the elicited after-effect or the speed of its decay, but there are some in whom after-effects are evoked only with great difficulty or else those who appear to show no such effects at all. Are these differences systematically related to other perceptual response categories, to more complex behavior variables, and finally to some presumed differences in cortical activity which is directly concerned with the absorption and trace perseverance of elemental and externally originated stimuli?

The present experimental investigation seeks to relate individual differences on a visual figural after-effect task to another perceptual response category, namely, *field dependence*. The relevance of this relationship may best become apparent when one understands that the basic operanda involved in perceptual measures of field dependence—field independence pertain essentially to a S's immediate and momentary relationship to a present stimulus field. Thus, "field independent" Ss can divorce themselves, so to speak, from the pushing and pulling forces of the immediate stimulus situation, while "field-dependent" Ss are more directly, concretely, and presumably passively bound to external stimuli and cannot transcend their particular pulls.

In the well known Rod and Frame Test, first used extensively by Witkin (1954) and his associates, the S is presented in an otherwise totally dark room with a tilted luminous bar surrounded by a luminous square frame which can be tilted, independent of the bar, by the examiner at various angles, and he is required to adjust the bar to its true vertical position while disregarding the various tilts of the frame. Typically, "field-independent" Ss are able to disregard the tilt of the surrounding frame and, drawing on some inner cues—such as perhaps their own body position—can establish the vertical position of the bar with relatively great accuracy, while "field-dependent" Ss, swayed by the tilt of the frame, make grossly inaccurate judgments regarding the true vertical position of the rod.

Since figural after-effects, and more specifically that aspect pertaining to the perception of the test figure following the fixation of the original inspection stimulus, also involve a S's relationship to an immediately present stimulus field, it is hypothesized that "field-dependent" Ss, being more affected by the attributes of an immediately present stimulus, should show weaker figural after-effects. And conversely, for "field-independent" Ss, i.e., Ss who are less tied to an "outer" and immediately present stimulus field, an "inner" cortical trace should be more potent, with the consequent occurrence of greater after-effect phenomena.

Method

The S groups, college students ranging in age from 19 to 23 years, were selected on the basis of their performance on the above described Rod and Frame Test. Only those Ss were chosen who had extreme scores in either the direction of field independence or field dependence. A consistent deviation from the true vertical of 10° or more constituted the field dependent group while those subjects who were able to locate the rod consistently within 3° of its true vertical position were placed in the field independent subject group. By this method the final S groups of 27 field independent and 19 field dependent were established.

All Ss were then exposed to a figural after-effect test illustrated in Fig. 1. This is a slightly modified version from similar geometric designs employed extensively in previous investigations and demonstrations of after-effects. The *I Figure* consists of two different sized squares, one measuring 1 in., the other 1.5 in., separated equally by 2 in. from their respective centers to the central fixation point. After a fixation time of 30 sec., the *T Figure*, consisting of two identical squares 1.5 in., was immediately presented to the S. The Ss were then asked to identify the test squares as "equal" or "unequal." Presence of the after-effect is demonstrated by a S's perception of the test squares as "unequal."²

Results and Discussion

Table 1 contrasts the Test Figure judgments for both the field independent and the field dependent S groups. The test data indicate clearly the presence of a signi-

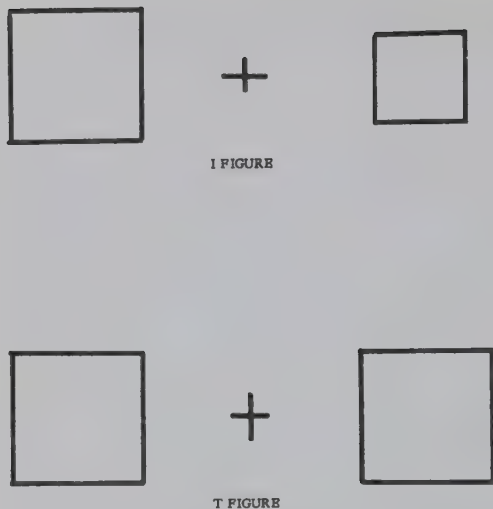


Fig. 1. The Ss are required to focus the central fixation point (+) of the I Figure for 30 sec., after which the T Figure is immediately presented for perceptual judgment. The left-hand square of the I Figure is identical with both squares of the T Figure (1.5 in.) while the right-hand I Figure square is smaller (1 in.). When the after-effect is operative, the right-hand T Figure square (presented in the same visual area as the previously fixated smaller square) is typically perceived as larger in comparison to the left-hand square.

significant difference ($p < 0.01$) in the perception of the test figures between the two S groups. As a group, the field independent Ss perceived the objectively equal test squares as unequal, while the dependent Ss did not report any size differences.

At this point it might be well to note that Witkin and his associates, who originally formulated the concepts of field dependence and field independence as used in this experiment go beyond the Ss' experimentally observed perceptual behavior, and relate these perceptual styles to broader behavior and personality variables. They offer evidence, for example, that field de-

Table 1. Figural After-effects

	+	-
Field Independent Subjects	20	7
Field Dependent Subjects	7	12

The (+) column indicates the number of Ss showing figural after-effects and the (-) column those who did not demonstrate the effect. The difference between the groups is significant ($\chi^2 = 6.14$ and $p < 0.01$).

pendent Ss, as measured by perceptual tasks, are also behaviorally dependent, passive, compliant, and typically insecure individuals, while perceptually independent Ss show a greater measure of independence in their personality functioning and are as a group more flexible, less group conforming, and creatively independent.

While the central aim of the present study is to demonstrate a relationship between two perceptual response categories, figural after-effects on the one hand, and a specific measure of field dependence on the other, and does not purport to assess directly broader personality or behavioral variables, the present data demonstrate, nonetheless, significantly different effects produced by simple visual stimuli upon cortical functioning for "field-independent" and "field-dependent" S groups: in the former, the stimulus leaves a cortical trace which has a telling effect upon the S's subsequent intercourse with new stimuli, while in the latter such effects are not demonstrated, and whatever cortical impact a continuously fixated stimulus may have, its subsequent trace is apparently obliterated by the impact of new and immediately present stimulus forces. The present data suggest that different neurophysiological processes exist, as far as the cortical absorption of a visual stimulus is concerned, for field dependent and field independent Ss. Should future research show that the magnitude of stimulus after-effects is systematically related to complex behavioral and personality variables, then we must also conclude that such broad behavior patterns might be in turn related to some elemental cortical process such as is exemplified by the impact of a single external stimulus and the relative strength of its subsequent trace.

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Notes

1. This study was supported by a faculty research fund, San Francisco State College, under the auspices of a National Science Foundation Institutional Grant.
2. In order to ascertain more unequivocally whether an after-effect had indeed been obtained, all subjects who perceived the T Figures as being "unequal" were required to specify this response. All these subjects identified "unequal" as meaning that the right-hand T Figure was "larger."

Evoked cortical response during vigilance

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In a conventional vigilance situation a relationship has been found between the averaged evoked cortical response to the vigilance stimuli and the Ss' ability to detect occasional, slight changes in these stimuli. The pattern of change in the evoked response that accompanied failures of detection suggested lowered arousal rather than distracted attention as the cause.

The amplitude of the evoked cortical response (ECR) in man has been found to vary with the attentional state of the S towards the stimulus concerned (Larsson, 1960; Garcia-Austt et al, 1961). Similar attentional states have been thought to play an important part in deciding the degree to which performance declines during prolonged vigilance (Mackworth, 1950; Broadbent, 1958). This study has attempted to bring together these two covariates of attention by recording the ECRs to the repetitive, 2-sec. click stimuli of a 2-hr. vigilance task and correlating these patterns with performance (detection of an occasional click slightly quieter than the rest).

Method

Five enlisted men and three college undergraduates carried out a vigilance test once, following a practice session. The S sat in an electrically shielded cubicle and listened to clicks from a loudspeaker 1 ft behind his head. Clicks occurred every 2 sec. for the duration of the test, 2 hr. During this period 16 softer clicks, attenuated by about 1-2 db, were randomly substituted for the regular ones. Four such "signals" occurred within each 1/2 hr. of the test. The S was instructed to report these events by pressing a key.

The clicks, about 40 db above the S's threshold, were produced by amplifying the output pulses of a Tektronix, Type 161 Pulse Generator and feeding them to an 8-in cone speaker behind the S. Scalp potentials were recorded between silver disc electrodes placed on the vertex and on the right mastoid process. Brain potentials were amplified by Tektronix Low Level Preamplifiers, Type 122. As the signal-to-noise ratio of ECRs to individual clicks is usually too low for useful measurement, an average was taken of the ECRs to the 50 clicks immediately preceding each signal. This was done by a Mnemotron Computer of Average Transients, which sampled the successive epochs of EEG following 500 msec. after each click. An average ECR was thus produced and recorded for measurement by hand on an X-Y Plotter. Each S contributed 16 such averaged ECRs (one associated with each of his 16 signals) from which measures of the amplitude and latency of the individual components were taken and correlated with signal detection performance.

Results

Figure 1 shows the variation over the 4 1/2-hr. periods of the test in (1) performance, in terms of signals heard, and (2) the amplitudes of three components of the ECR: a negative deflexion (n_1) whose peak latency was about 95 msec.; a positive deflexion (p_2), latency about 170 msec.; a later negative deflexion (n_2), latency about 265 msec. The significance of changes in these parameters during the course of the test was assessed by the Average Spearman Rank Order Correlation Coefficient (Lubin, 1961). They were as follows: performance declined, but the trend was not significant; the amplitude of P_2 declined ($p < .05$), although there was a reversal of this trend from 3rd to 4th 1/2-hr; the amplitude of n_2 increased consistently ($p < .01$); there was little change in n_1 . Measures were also taken of the peak latency of the three components of the ECR but these showed no significant trends over the 4 1/2-hr. periods of the test.

The possibility of a relationship between the trends of performance and ECR was examined by comparing the ECRs preceding missed and detected signals, see Table 1. Missed signals were associated with greater amplitude of n_2 (in 8 out of 8 Ss, $p < .01$) and with

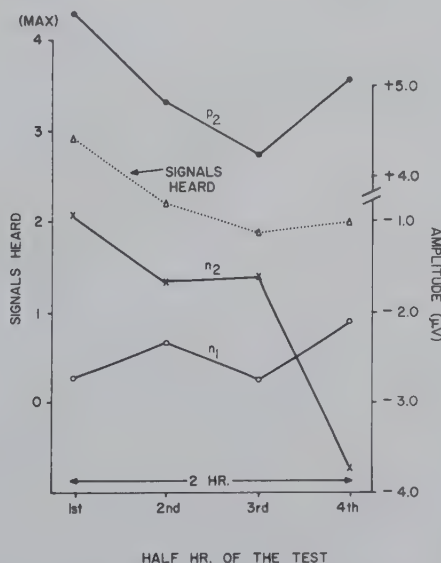


Fig. 1. Amplitude of first negative (n_1), second positive (p_2) and second negative (n_2) components of the evoked cortical response (ECR) and the associated level of signal detection.

Table 1. Amplitude and latency of the components n_1 , p_2 and n_2 of the ECRs preceding missed and detected signals (* indicates a difference between missed and detected signals which is significant at $p < .02$, ** indicates the same at $p < .01$).

	Amplitude (μ v)			Latency (msec)		
	n_1	p_2	n_2^{**}	n_1^*	p_2	n_2
Detected	-2.55	+5.06	-1.36	93.8	172.0	264.0
Missed	-2.39	+4.94	-3.00	102.5	167.0	268.0

greater latency of n_1 (in 7 out of 8 Ss, $p < .02$ using the Wilcoxon Test (Siegel, 1956)). Since these relationships held even for the unusual Ss who registered more misses during the first than the second half of the test (i.e. showed no vigilance decrement), it follows that these relationships were not due merely to the chance association of unconnected trends in ECR and in performance towards the end of the test. The amplitude of p_2 and latency of n_2 , whose temporal trends also paralleled those of performance, failed to distinguish between missed and detected signals.

The amplitude of n_2 and the latency of n_1 , then, appear to be reflecting neurophysiological changes associated with the decline in performance during prolonged vigilance. The amplitude of p_2 , on the other hand, may reflect changes which parallel the decline in vigilance, but which are not related so closely to it. The amplitude of n_1 and latency of p_2 show no clear trends during the course of the test and do not appear to be related to performance.

Discussion

These findings constitute one of the few demonstrations of a link between neurophysiological function and vigilance performance. They provide also the first statistically significant demonstration of a relationship between the ECR and the course of the vigilance decrement. If these techniques can be refined and simplified, the ECR might well form an important part of any physiological indicator of the state of alertness of the human operator.

Two behavioral explanations of the vigilance decrement in performance are relevant here. One suggests that it is due to extraneous stimuli distracting the S's attention from those connected with the task (Broadbent, 1958). Another derives from the finding that vigilance decrements are markedly accentuated by loss of sleep (Wilkinson, 1960) and suggests that they are due to a decline in the level of arousal of the S. Evidence on the response of the ECR to various attentional states may help us to assess the nature of the decrement in the present study. It has been reported that the overall amplitude of the ECR declines as attention is diverted from the stimuli which produce it (Garcia-Austt et al, 1964; Gross et al, 1965; Satterfield, 1965) and increases when a discriminatory response has to be made to the stimuli (Larsson, 1960; Chapman & Bragdon, 1964). "Overall amplitude" commonly means the distance between the most prominent positive and negative com-

ponents of the ECR, which in these studies were n_1 and p_2 . It would seem reasonable therefore to associate a diversion of attention from the stimuli with a reduction in the amplitudes of these two components, n_1 and p_2 . A fall in the general level of arousal, on the other hand, as in the transition from waking to sleep (Williams et al, 1962; Weitzman & Kremen, 1965), is associated mainly with a marked increase in the amplitude of n_2 and comparatively little variation in n_1 and p_2 . Now in the present vigilance test it was this latter change, the increase in n_2 , which was associated with failures of detection. The implication is therefore that it was declining arousal rather than distracted attention which led to lowered performance. This conclusion must be qualified in two ways: (1) While it may be valid in the present vigilance setting it may not hold for others. For example, where the signal frequency is higher the diversion of attention may contribute more than declining arousal to the vigilance decrement (Haider et al, 1964). (2) If changes in the direction of attention are more transitory than those of arousal an ECR measure based on a time-base shorter than the present one (which had to sample 50 stimuli, a period of 1 min. 40 sec., before each signal) might be more sensitive to these changes.

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Notes

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Separation thresholds for colored bars with and without luminance contrast¹

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Separation thresholds for rectangular bar targets were obtained for certain combinations of black, white and colored targets and grounds. Relatively low threshold separation scores were obtained with colored targets against white grounds with targets and ground equated in luminance. The results suggest that color contrast is sufficient but less efficient than luminance contrast for visual acuity.

Theories of visual acuity have been mainly theories of intensity or contrast discrimination. Most investigations which have included color, or more properly, wavelength as a variable, have been concerned with questions of improving contrast or luminance gradients at the critical contours. Typically, but not unanimously, these investigators have used black targets on colored grounds and have found acuity to be best with illuminants from the yellow to green region of the visual spectrum and relatively worse with illuminants from the extremes of the spectrum.

The fact that color contrast alone may be a sufficient basis for visual acuity has been indicated by some work (e.g. Eastman Kodak Company, 1944) but most of the small amount of data available is fragmentary or gathered under special observation conditions which render evaluation and integration of the data difficult at best.

The present preliminary study with simple targets and viewing conditions is one of a series initiated with the goal of gathering more information on color contrast as a variable in visual acuity.

Subjects

One female and three males, ages 21 to 37, served in the experiment. The three males wore corrective lenses and all Ss scored 1.0 or better in the far and near monocular visual acuity test on the AO Ortho-rater. All Ss scored 100% on the Ishihari and the AO tests for color deficiency.

Method

The stimulus configuration presented to the S was a pair of rectangular bars seen against a circular ground. The bars subtended a visual angle of approximately 0.5° in width and 1.1° in height at 63 cm, and the ground an angle of 7° . A larger annular surround concentric with the ground increased the illuminated field to approximately 22° . The optical arrangement of the apparatus was such that light from a single 450-W Xenon source was directed to three secondary diffuse sources for the surround, ground and targets respectively. The light from these sources was directed to the S's eye in a modified Maxwellian manner. This arrange-

ment allowed independent control of the luminance and color characteristics of the display elements. The annular surround was always white with a luminance level set at the 5 ft-L level used for the ground and targets. Target and ground colors were controlled with Corning and Wratten filters. The filters used and their calculated dominant wavelengths were: C-(Corning) 2-59, 640 nm; Wratten No. 73, 571 nm; C-4-64, 528 nm; C-5-60, 458 nm.

During an experimental session the S was comfortably seated before the apparatus with his eye position rigidly controlled and fixed with use of an adjustable bite board bearing his dental impression. Observation was monocular with a 3-mm artificial pupil.

After 1/2 hr. dark adaptation the S was positioned and light adapted to white light at 5 ft-L for 5 min. After 10 practice adjustments with black targets presented on a white ground he was then adapted to the white for 2 min. after which the first test stimulus condition was presented.

The task for the S was to make two sorts of adjustments of the target bar pair. With the bars well apart he brought them together to the point at which the line of separation just was not seen, a together judgment. This setting was read from a calibrated dial on the target carriage mechanism and the targets were then moved more closely together. The S then moved the targets apart until he just perceived a line of separation, an apart judgment. Ss were allowed to bracket the judgment point but were restricted to making the last movement in the indicated direction. The Ss made five pairs of judgments for each stimulus combination with a 1-min. adaptation to white light between each combination. Thresholds were obtained for all combinations during a single session, and four counterbalanced replications were obtained for each S.

Results and Discussion

The curves in Figs. 1 and 2 show the mean separation threshold scores for all Ss combined. Each point is based on 20 pairs of judgments for each of the four Ss. The curves are representative although details differed between Ss.

In Fig. 1, curve B/C shows the separation threshold scores obtained with black targets presented against colored grounds. The pattern of the obtained scores, low with the yellow and greater with the blue and red grounds, is consistent with acuity data gathered with use of black bars on colored grounds (Ferree & Rand, 1931) and black grids on colored grounds (Shlaer et al, 1942).

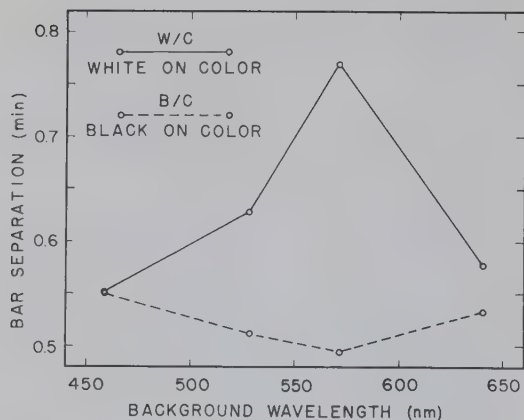


Fig. 1. Mean detectable bar separation of $0.5^\circ \times 1.1^\circ$ white and black bars presented on different colored grounds.

Curve W/C shows the data obtained with the white bars presented on colored grounds. The inverted pattern of the data, with very large separation scores for the white on yellow condition seems to reflect mainly the loss or change in color contrast between the bars and the thin colored line of separation. So called small angle tritanopia and the perceptual loss of color of very small stimuli has been discussed by many investigators (e.g. Middleton & Holmes, 1949). Both the separation scores and subjective report of the observers in the present experiment parallel previous qualitative descriptions of the perceptual changes. Very small yellow and green stimuli appear white or light grey, red and blue appear dark grey or black; and the loss of color occurs at larger angular size with yellow and blue stimuli than with green and red.

In Fig. 2 the scores obtained with colored targets on a black ground are shown in curve C/B. With the exception of the data obtained with the blue targets the scores run notably higher than those obtained with the black-on-color configuration. Previous investigators have noted similar results and have discussed the problem of this type of results. On the basis of a simple intensity- or contrast-discrimination theory of visual acuity no difference is predicted since the retinal intensity distributions for the two contrast directions are mathematically complementary (Byram, 1944).

In curve C/W are shown the data obtained with colored targets on a white ground. The pattern of the

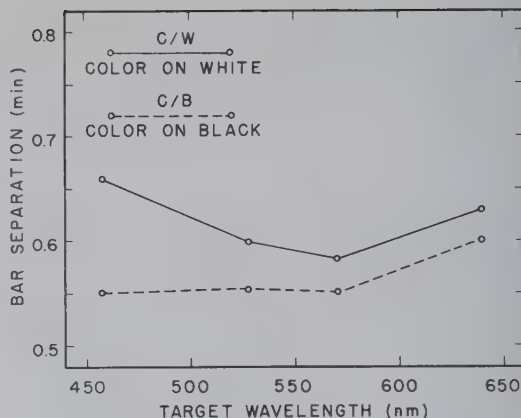


Fig. 2. Mean detectable bar separation of $0.5^\circ \times 1.1^\circ$ colored bars presented on white and black grounds.

scores is the same as that obtained with the black on color configuration with all separation thresholds raised approximately 0.1 min. The relatively low scores clearly suggest that reasonably good visual acuity may be obtained with target ground configurations presenting color contrast only, although high luminance contrast may be a more efficient basis for the discrimination. The results of the experiment suggest, however, that both type and direction of contrast must be considered in an attempt to predict the separation threshold level for a given stimulus ground configuration.

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Note

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Recognition and recall of high frequency words following serial learning¹

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A set of 50 words relatively devoid of sequential dependencies (in random order) were administered with degree of training varied for independent groups of Ss. A single test of recall or recognition followed. For most of the range of training, recognition was superior to recall; but with a sufficiently large number of trials, recall surpassed recognition. The results, taken together with previous data, suggest that studies comparing different retention measures by simple ordering are likely to become exercises in futility. Implications were briefly examined for the hypothesis of a unitary construct underlying recognition and recall.

Recognition measures of memory have generally yielded higher retention scores than free recall measures following identical conditions of training. More recently, the superiority of recognition to recall was found only at early stages of serial verbal learning. At later stages, recall was superior to recognition (Lachman & Field, 1965). The training material in that experiment was an "English paragraph" consisting of 50 different high frequency words in syntactical order. Thus, a fixed list at a high approximation to English (AE) was administered for varying series of trials prior to a single retention test. The test was either conventional free recall or binary recognition (Lachman & Tuttle, 1965) containing a random order of the training words intermixed with distracter words. Both sets of words were selected from a population of high frequency lexical units, the distracters were selected randomly. The test words, during recognition, were sorted into old or new categories at the rate of one word per 1.5 sec. Pacing of recognition was designed to preclude contamination of the recognition measure by implicit serial recall. Perfect recall was obtained after 16 trials. Approximately 80% of the training words were correctly recognized at all levels of training, including 128 trials (see Fig. 1).

Waugh (1961) has demonstrated that free recall instructions yield a higher absolute number of words recalled after moderate amounts of training than do serial recall instructions. On later trials, the total number recalled is greater for serial recall than for free recall. Perhaps serial recall instructions induce the Ss to organize and to learn the words on a serial basis such that recall is materially facilitated on later trials by a given word cueing the next word in the sequence. Lachman and Field specifically instructed their Ss to attempt to learn the training words in sequence. A high AE list, such as the "prose" material used in that experiment, provides the sequential dependencies that make serial organization the most ef-

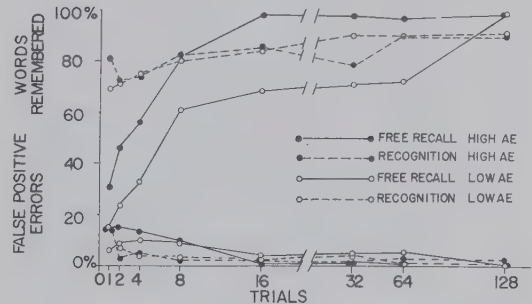


Fig. 1. Mean percentage correct (above) and false positive errors (below) as a function of number of training trials and type of retention test. Clear circles represent data from the present experiment; the curves connecting the black circles are from Lachman & Field (1965).

ficient encoding strategy provided that retention is tested by recall. Recognition, including the binary recognition test, is typically insensitive to serial organization. The contextual cues provided by sequence and chaining are, therefore, useless. Accordingly, recall surpassed recognition in the Lachman and Field study after the sequential dependencies were strengthened by sufficient training.

Barring sampling accidents, a random set of words initially is devoid of sequential dependencies. Training with a fixed order of presentation, however, probably induces a serial learning strategy such that sequence associations start developing. In any case, if S is directed to a serial learning strategy, recall may once again surpass recognition after sufficient training. The present study compares recognition and recall after various degrees of training with a randomly ordered list of words (low AE).

Method

The present experiment consisted of a training phase followed by either a free recall or recognition test. It was identical in all respects to the Lachman & Field (1965) experiment, except for the order of training words. Ten different random orders of the previous training list were employed, one such order for each of the 10 Ss in a given treatment. The training list consisted of 50 different words selected from the 1000 most frequent English words (Thorndike & Lorge, 1944). A training trial consisted of one exposure of the entire list. Independent groups of Ss received 1, 2, 4, 8, 16, 32, 64, and 128 trials. The intertrial interval was 60 sec. Ss in the 32, 64, and 128 trial groups were given a 5 min. rest between trials 16

and 17. The 64 and 128 trial Ss, however, were trained for two and four consecutive days, respectively, with 32 trials administered each day. Each word was printed on a separate IBM card. The Ss exposed one word and covered the previous word every 1.5 sec. by turning the cards in time with clicks from a tape recorder.

Prior to training all Ss were directed to try to learn the words in the fixed order of presentation. Immediately after training, the assigned testing procedure was described and Ss in the free recall condition wrote down all words remembered. Word order on the test was optional and no time limit was imposed. Ten sets of 50 new words were sampled from the same language population for the recognition test. These distracter words were mixed randomly with the training words. One card containing one word was sorted every 1.5 sec. into "recognize" or "don't recognize" categories. The Ss were 149 Introductory Psychology students; four additional Ss were discarded.

Results

The results including Mann-Whitney U-tests are presented in Table 1. Each mean represents the scores for an independent group of 10 Ss with the exception of the 128 trial conditions. These nine Ss (one S was lost due to illness) were tested first for recognition followed immediately by free recall. This order of testing intentionally biases the data against free recall: unpublished parametric data indicate that in general the second retention test, whether recognition or recall, yields a lower score compared to the score obtained when it is administered first. The results are presented graphically in Fig. 1 along with Lachman and Field's data. Percentages of words correctly recalled and recognized are plotted against training trials in the upper section of the graph. False positive errors, words not on the training list that were recalled or recognized, are plotted at the bottom as a proportion of the number of training words, 50. This is merely a convenient method of description, no inference is intended.

Discussion

The results indicate that recall ultimately surpasses recognition even with training materials consisting of words in random order. Apparently, sequential dependencies develop relatively slowly during serial learning of a low AE list such as the present set of randomly ordered words. The crossover of recognition and recall

occurs considerably later with a low AE list as compared to a high AE list (see Fig. 1), but it does occur. These findings suggest that comparisons of different retention measures that consist of simple orderings of scores may be meaningless. This conclusion is not compromised by the present procedure of "setting" the S for serial learning. In matter of fact, the conclusion is strengthened. For, if the relative efficiency of recall and recognition depends on learning instructions administered to S, then simple orderings of retention measures are even more vacuous. The suggestion that instructions may differentially influence various retention measures is not mere fancy but is soundly based on data. Eagle & Leiter (1964), in an incidental learning experiment, have demonstrated that a proper orienting task will enhance recognition over recall where recall was superior to recognition for intentional learners. This would further suggest that recognition and recall are not more or less sensitive indicators of an underlying unitary construct. Rather, it is likely that recognition and recall are differentially influenced by implicit and explicit learning patterns, by which we mean, second order habits in S-R language, strategies in cognitive language, or program control in an informational science oriented language. If these processes prove to be central to complex human learning, then computer simulation is likely to become more important for modeling these processes.

Although the present experiment and the Lachman & Field (1965) study were conducted with an interval of one college semester, a cautious comparison may be of interest. Figure 2 would seem to indicate that recognition memory is invariant with respect to order of AE. Of the eight different degrees of training for which data is available, all but two show virtually identical means for high and low AE. It might be tempting to conclude that superior word recognition for high AE material after one training trial is best attributed to random variation. However, Lachman & Tuttle (1965) consistently rejected this hypothesis for a variety of training conditions. The data presented in Fig. 2 suggest that degree of training interacts with order of AE to influence recognition memory in a fashion that warrants intensive investigation.

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Note

1. Supported by MH-10764.

Table 1. Mean words correct and Mann-Whitney U Test for $n_1=n_2=10$

Trial	Mean words correct		U	p
	Recognition	Recall		
1	34.4	7.3	0	<.001
2	35.6	12.0	0	<.001
4	37.6	16.6	1	<.001
8	40.1	30.5	18	<.02
16	42.0	34.2	23	=.05
32	45.0	35.5	24	--
64	44.8	36.2	49	--
128	45.6	49.7	†	<.001

* Randomization test for matched pairs, $n=9$

The effect of a pratfall on increasing interpersonal attractiveness¹

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An experiment was performed which demonstrated that the attractiveness of a superior person is enhanced if he commits a clumsy blunder; the same blunder tends to decrease the attractiveness of a mediocre person. We predicted these results by conjecturing that a superior person may be viewed as superhuman and, therefore, distant; a blunder tends to humanize him and, consequently, increases his attractiveness.

If we assume that superior intellectual ability is a positive attribute and if we assume that people with positive attributes are more attractive than those with neutral or negative attributes, it seems obvious that, all other things being equal, we should like people of superior intellectual ability more than mediocre, average, or stupid people. Yet, obvious as this relationship may seem, it is not always the case. For example, it has been shown that group members who are considered the most able are not necessarily the best liked (Hollander & Webb, 1955). It has also been demonstrated that people who initiate the most ideas and are acknowledged as the best "idea" men by other members of their group are usually not the best liked group members (Bales, 1953, 1955, 1958; Bales & Slater, 1955).

The rejection of a person of high intellectual ability may be due to an incompatibility between proficiency in intellectual and social roles; i.e., individuals of high intellectual ability may be brusque or unpleasant interpersonally. What we are proposing is a totally different explanation for this phenomenon—one that involves intellectual ability *per se*. A great deal of ability, in and of itself, might make the stimulus person seem "too good," unapproachable, distant, non-human. This might occur even if his social skills were the equal of his less able counterpart. If this were the case, some evidence of fallibility may raise the individual's attractiveness. A near perfect or superior individual who shows that he is capable of an occasional blunder or pratfall may come to be regarded as more human and more approachable; consequently, he will be liked better *because* of this pratfall. On the other hand, if a mediocre or average person commits an identical blunder, he will not undergo an increase in attractiveness. Indeed, since it would suggest only that he is *very* mediocre, it should lower his attractiveness. Consequently, we are predicting an interaction between ability and pratfall.

Procedure

The Ss were 48 male sophomores recruited from an introductory psychology course at the University of

Minnesota. For the sake of economy, Ss were run in groups of two; they were separated by a cardboard screen and were not permitted to communicate in any way.

The general procedure involved having the S listen to one of four tape recordings of a stimulus person. On one tape the stimulus person was one of very high ability; on another he was a person of average ability. On a third tape the person of high ability committed a clumsy and embarrassing blunder; on a fourth tape the person of average ability committed an identical blunder. At the end of the tape each S was interviewed and asked for his reactions to the stimulus person by one of two interviewers. The assignment of Ss to experimental condition and to the interviewer were randomly determined.

The experiment was described as a study of impression formation. Ss were told that they would be listening to a tape recording recently made of a student trying out for the College Quiz Bowl team. E informed the Ss that after hearing the tape they would be asked to state their impressions of the student. The tape was actually a contrived one in which the stimulus person was asked 50 difficult quiz questions. The tapes used in the four experimental conditions were identical except for manipulations of ability and pratfall.

Superior Ability: On two of the tapes the stimulus person answered 92% of the questions correctly. Furthermore, during an interview, he admitted (modestly) that, in high school, he had been an honor student, yearbook editor, and a member of the track team.

Average Ability: On two tapes the stimulus person answered only 30% of the questions correctly. During the interview he admitted that he received average grades in high school, was a proof-reader on the yearbook, and had tried out for the track team but failed to make it.

Pratfall: Near the end of the interview the stimulus person clumsily spilled a cup of coffee all over himself. On the tape this blunder was accompanied by a good deal of noise and clatter, the scraping of a chair, and the stimulus person's anguished statement, "Oh my goodness, I've spilled coffee all over my new suit." The coffee-spilling incident was taped, duplicated, and spliced onto one of the Superior Ability tapes and onto one of the Average Ability tapes. After the tape was played, E led S to one of two rooms, assigned him to one of two interviewers, and left the room. The interviewers, who were ignorant of S's experimental condition, asked S eight questions pertaining to his

impressions of the stimulus person plus a few filler questions. As a check on the manipulation of ability, S was also asked to rate the stimulus person's intelligence. S answered each question orally and also indicated the intensity of his feeling on a scale ranging from -7 to +7.

Results and Discussion

The results indicate that the manipulation of ability was successful; Ss in the Superior Ability conditions rated the stimulus person more intelligent ($M=5.73$) than in the Average Ability conditions ($M=0.83$; $t=6.89$, $p<.005$).

A composite attractiveness score was computed for each S by summing the numerical responses given to the eight interview questions assessing the S's attraction to the stimulus person. Table 1 lists the mean attraction scores by experimental condition. Inspection of Table 1 shows that the most attractive stimulus person was the superior person who committed a blunder ($M=30.2$) while the least attractive stimulus person was the average person who committed a blunder ($M=-2.5$). The data were analyzed by analysis of variance. There was a significant effect due to ability—Ss indicated a greater liking for the Superior Ability person than the Average Ability person ($F=14.90$, $df=1/40$, $p<.001$). This main effect must be qualified by a significant interaction between ability and pratfall ($F=10.33$, $df=1/40$, $p<.01$). The pratfall had the effect of increasing the liking the S had for the person of superior ability while the same pratfall decreased his liking for the person of average ability. These results confirmed our hypothesis. The effect of the pratfall, by itself, was insignificant. There were no significant interviewer effects.

Thus, within the range of ability varied in this experiment, higher ability leads to greater attractiveness;

Table 1. Mean Attraction Scores

	Pratfall	No Pratfall
Superior Ability	30.2	20.8
Average Ability	-2.5	17.8

Comment on Murray and Kohfeld by Robert Adamson

Murray & Kohfeld (1965) interpret stimulus intensity dynamism in terms of the relation between pre-test AL and test signal intensities. An alternative assumption is made about the AL for one of their groups, and a reinterpretation of their findings is offered which incorporates a tension level intermediary between the aforementioned relationship and performance.

Results reported by Murray & Kohfeld (1965) in a study pertaining to stimulus intensity dynamism are consonant with those reported in earlier studies on reinforcement effects (Bevan & Adamson, 1960; Black, Adamson, & Bevan, 1961) which also utilized an adapta-

however, the pratfall does not have this uniform effect. Whether a pratfall increases or decreases the attractiveness of a person depends upon the level of his ability. A contrast comparing the difference between the Pratfall and the No Pratfall conditions within the Superior Ability ($M_D=+9.4$) condition and within the Average Ability ($M_D=-20.3$) condition is highly significant in the predicted direction ($t=3.18$, $p<.005$). Furthermore, separate contrasts for the Superior and Average Ability conditions lend additional support to the hypothesis. In the Average Ability-No Pratfall condition the stimulus is rated as significantly more attractive than in the Average Ability-Pratfall condition ($t=3.15$, $p<.01$). However, the comparison between the Superior Ability-Pratfall and Superior Ability-No Pratfall conditions, while in the expected direction, does not reach statistical significance ($t=1.45$, $p<.18$).

Taken as a whole, these data support the contention that a blunder on the part of a superior person removes the onus of being "too good"; it increases his approachability and makes him seem less austere, more human—while a blunder on the part of a mediocre person makes him seem that much more mediocre.

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Note

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tion level model. An alternative interpretation of the results is suggested, however, if a different assumption is made about one of the groups in the study.

Murray and Kohfeld pre-adapted three groups, respectively, to 40 db tones, 100 db tones, and silence (presumably, about 10 db). They tested reaction time (RT) for the groups to randomized presentation of auditory signals having a geometric mean of 70 db. "It was anticipated that the effective AL during RT trials would be near 40 or 100 db for Ss initially adapted at those levels and near the geometric mean of the test intensities (70 db) for Ss adapted to silence. Thus it was expected that mean RTs at all levels of signal intensity would be

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R-S recall and recognition as functions of stimulus and response meaningfulness¹

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Meaningfulness (*M* as defined by association value of nonsense syllables) for both *S* and *R* components of paired associates was related to *R-S* recall and recognition. *R-S* recall was significantly related to *S* *m* but not to *R* *M*. Neither *S* *M* nor *R* *M* had a significant effect on *R-S* recognition. The results were interpreted as evidence against an intratrial rehearsal view of *R-S* learning.

Numerous studies have indicated that *S-R* paired-associate learning is a function of meaningfulness (*M*) for both the *S* and *R* components, but with the effect being more pronounced for *RM* than for *SM*. Considerably less information is available relating both *SM* and *RM* to *R-S* learning. Cassem & Kausler (1962) reported a direct monotonic effect for *SM* on *R-S* acquisition, but they did not vary *RM* concomitantly. Two studies in which *SM* and *RM* were varied simultaneously obtained conflicting results. Hunt (1959), in a factorial study employing disyllabic words as *S* and *R* components of high (*H*) and low (*L*) *M*, found a pronounced positive effect for *SM* but a much weaker positive effect for *RM*. On the other hand, Cautela (1965), in a nonfactorial study that departed in several important ways from most other paired-associate studies (including the use of heterogeneous materials to manipulate *M*—nonsense syllables for *LM* and words for *HM*), found a greater positive effect for *RM* than for *SM*. As a further test of the relative effects of *SM* and *RM* on *R-S* learning, the present study, like that of Hunt, employed a factorial design with *HM* and *LM* nonsense syllables as the *S* and *R* components. *R-S* learning was measured by both the recall and the recognition of *S* components.

Method²

The *Ss* were 80 undergraduate students. They were assigned alternately to the four conditions (*N* = 20) of the 2 by 2 factorial design resulting from two levels of *M* (*H* and *L*) as varied in both the *S* and *R* components of a paired-associate list. Thus the four conditions, defined in terms of *S-R M* combinations, were *HH*, *HL*, *LH*, and *LL*.

The *H* and *L* syllables were selected from the 80-100% and 0-20% ranges, respectively, of Archer's (1960) norms. There were six paired associates in each list and intra-list similarity of letter content was minimized as much as possible. Following practice on a warm-up list, the pairs on the experimental lists were projected onto a small screen by a Carousel projector. The blocking or recall method was employed, with alternating study and test trials. During the study

trials each pair was exposed for 2 sec. Each test trial was for 30 sec.; during this period *S* was handed a sheet of paper listing the six *S* components and was instructed to write the *R* components in juxtaposition to the appropriate *S* components. Practice continued to a criterion of one perfect *S-R* test trial. Immediately after the last *S-R* test trial one 30 sec. *R-S* recall trial was given in which the *R* components were listed on a sheet of paper and *S* wrote down the *S* component associated with each *R* component. Finally, a *R-S* recognition trial was given following precisely the procedure of Leicht & Kausler (1965).

Results and Discussion

Summary data for trials to *S-R* criterion, *R-S* recall (number of *S* components correctly spelled), and *R-S* recognition (number of *S* components correctly identified) are given in Table 1. For trials to *S-R* criterion an analysis of variance yielded a highly significant positive effect for *RM* (*F*, 25.13; *df*, 1/76; *p* < .001) and a significant positive effect for *SM* (*F*, 6.34; *df*, 1/76; *p* < .02). The *SM* by *RM* interaction effect was clearly not significant (*F* < 1). The analysis of variance for *R-S* recall yielded a highly significant positive effect for *SM* (*F*, 24.44; *df*, 1/76; *p* < .001). However, neither the main effect for *RM* nor the *SM* by *RM* interaction effect approached significance (*F*, 1.38; *df*, 1/76; *p* > .20 and *F* < 1, respectively). An analysis of covariance with trials to *S-R* criterion as the adjusting variable failed to make an appreciable difference on the effects of *SM* and *RM* on *R-S* recall. The averaged within-group *r* trials to *S-R* criterion and amount of recall was only -.01. Neither of the main effects nor the interaction effect approached significance for the *R-S* recognition measure (all *ps* > .10).

The present results are therefore in agreement with Hunt's earlier findings obtained with words rather than nonsense syllables as *S* and *R* components. *SM* seems to be a more potent variable related to *R-S* recall than is *RM*. However, neither *SM* nor *RM* had an appreciable

Table 1. Summary Data for Trials to *S-R* Criterion, *R-S* Recall Scores, and *R-S* Recognition Scores

Condition	Measures					
	<i>S-R</i> Trials		<i>R-S</i> Recall		<i>R-S</i> Recognition	
	Mean	SD	Mean	SD	Mean	SD
<i>HH</i>	6.65	4.45	3.50	1.50	5.10	.85
<i>HL</i>	16.70	9.15	2.90	1.77	4.75	.96
<i>LH</i>	11.45	9.23	1.70	1.38	4.90	.85
<i>LL</i>	21.80	13.21	1.55	.89	4.55	1.39

effect on R-S recognition when S-R acquisition was taken to mastery of the list. Leicht & Kausler (1965) had previously failed to find an effect for SM on R-S recognition. The present results corroborate this finding and, in addition, suggest that RM may also be unrelated to R-S recognition.

These results are contrary to the interpretation of R-S learning in terms of intratrial rehearsal that was recently offered by Wollen & Gallup (1965) and thus provide some indirect support for an associative symmetry interpretation of R-S learning. If R-S recall is the product of S-R-S-R-S-R intratrial rehearsal, as proposed by Wollen and Gallup, the effect of RM on R-S recall would be expected to be as pronounced as the effect of SM. Because of the greater ease of pronunciation and greater degree of prior integration, R components of HM should generate considerably more S-R-S-R-S-R rehearsal during the study trials than R components of low M, thereby leading to greater R-S recall scores. This was not found in the present study.

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fastest for the 40 db group (as test signals were at or above AL), slowest for the 100 db group (test signals were at or below AL), and intermediate for the silence group."

The above statement makes the critical assumption that Ss do not adapt to silence. If the contrary assumption is made, the AL for the silence-adapted group should be lower than those of the other two groups during the RT trials and the relative signal intensity greatest. The groups would be ordered on a relative signal intensity dimension (geometric mean intensity of the RT signals, at 70 db, minus pre-RT AL) as follows:

Pre-test AL	Test Signal	Difference
Silence	70 db	circa 60 db
40 db	70 db	30 db
100 db	70 db	-30 db

If this is the case, an alternative explanation of Murray and Kohfeld's findings is necessary. The one suggested here is afforded by the Bevan-Adamson (1962) model for reinforcement. This model assumes a tensional intermediary between the difference, intensive input minus AL, and resulting performance. Accordingly, there would be a direct relationship between relative signal intensity and presumed tension level for the groups in Murray and Kohfeld's study.

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Notes

1. Based on a Master's thesis by J. S. under the direction of D. H. K.
2. An additional two level variable in the study was type of instructions. However, the effect of this variable, and its interactions with other variables, was extremely slight on all criterial measures and was omitted from the present study.

A further assumption of the Bevan-Adamson model is that tension-level is curvilinearly related to performance in the form of an inverted U, an assumption well supported experimentally (e.g. Courts, 1939, Shaw, 1956, Yerkes, & Dodson, 1908). On the basis of it, it would be expected that the group pre-adapted to 40 db would represent an intermediate—and possibly optimal—tension level and should show the fastest RT, whereas the other two groups, representing high and low tension levels, should show less efficient performance. This expectation is in accord with the findings of Murray and Kohfeld.

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Reported mediation as a function of degree of learning

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The effects of 10 practice trials beyond a criterion of two perfect trials on reported mediation was investigated in an AB, BC, AC paired-associate learning task. Significantly more "direct" responses were reported after the 10 additional trials than after the two perfect trials. Significantly more explicit mediation was reported for facilitation pairs and there was no evidence for "unconscious mediation."

It is a common observation that during early stages of learning responding is accompanied by a great deal of mediational activity and that this activity tends to decrease with practice (O'Brien, 1921; Solomons, 1899). In paired associate learning, for example, mnemonic devices may initially mediate responses but eventually drop out with the responses becoming automatic (Barnes & Underwood, 1959; Reed, 1918). This relationship was also described by James (1896): "...habit diminishes the conscious attention with which our acts are performed."

It has also been reported that the learning may be influenced by mediation even though Ss do not report the conscious use of it. For example, Bugelski & Scharlock (1952), employing the AB, BC, AC, mediation paradigm, found facilitation of AC learning with no S "consciously" resorting to the use of the B syllable. Russell & Storms (1955) reported similar findings with norm-inferred mediational chains. However, Martin & Dean (1964) found no evidence to support the interpretation of unconscious mediation in the Russell-Stroms task.

The present study was designed to explore the effects of practice beyond a criterion on verbal reports of mediating activity in a paired associates learning task. Additionally, the study was to serve as a partial replication of the Bugelski-Scharlock study.

Method

Three lists, each containing eight nonsense syllable pairs, were constructed from the 16 item lists used by Bugelski and Scharlock. The AB, BC, AC sequence was used with a "mixed" AC list consisting of four facilitation and four interference pairs. The A and C terms of a facilitation pair had been paired with a common B term in the previous lists. The A and C terms of an interference pair had been paired with different B terms in the previous lists. There were two forms of the final list: each A and C term of a facilitation pair of one form served in different interference pairs on the other form and vice versa.

The stimulus and stimulus-response pairs were typed on separate 3 x 5 in. white cards, photographed and made into 35 mm. slides. Five different random orders of each list were constructed and were projected onto a white screen by means of a Carousel projector at a 2:2 second rate. There were no blank slides between orders and the anticipation method was used. Ss sat about 15 ft. from the screen.

Each S learned the first two lists to a criterion of two perfect trials (not necessarily consecutive). One group learned the third list to two perfect trials; the other group was given 10 additional

trials beyond the second perfect trial. The interval between the end of one list and the beginning of the next was approximately 2 min.

After reaching criterion on the third list, the stimuli of this list were read to S who was instructed to tell E, "Exactly what came to your mind when you saw that syllable on the screen. If nothing but the response syllable, just say the response; if you thought of something else in addition to the response syllable, tell me what it was." When this procedure had been completed for each of the stimuli, S was read the stimulus and response terms of the final list and was asked, "Tell me what you did to learn the response syllable, what you thought of when you were trying to learn the response syllable."

The Ss were introductory psychology students at Syracuse University (summer session) who participated in experiments as a part of their course requirement. The design was a 2 by 2 by 2 factorial (criterion, sex, form of list) with five Ss in each cell. The Ss were assigned to the criterion conditions alternately and to the form of the list in two's, males and females being assigned separately according to this sequence.

Results and Discussion

A mixed analysis of variance on the mean number of trials to criterion on each list for each group yielded significant effects due to Lists ($F=28.915$, $df=2/64$, $p<.001$), and the interactions Criterion by Sex by Form ($F=9.512$, $df=1/32$, $p<.01$), and Criterion by Sex by Form by List ($F=5.992$, $df=2/64$, $p<.01$). These interactions resulted from a differential effect of "Form" on learning AB and BC lists, an effect which must reflect a bias in assigning Ss to groups as "Form" did not differ until the AC list. A separate analysis was performed on the number of trials to criterion on the AC list and the only significant effect due to sex, with females requiring fewer trials than males ($F=4.355$, $df=1/32$, $p<.05$). Thus, except for sex, groups were reasonably equated on learning of the AC list.

A mixed analysis of variance (Criterion, Form of List, Kind of Pair, Trials) on correct anticipations for the first five trials on the AC list yielded significant effects due to Trials ($F=130.478$, $df=4/128$, $p<.001$); Kind of Pair (Facilitation-Interference) ($F=13.524$, $df=1/32$, $p<.001$); and Form by Kind of Pairs ($F=5.868$, $df=1/32$, $p<.05$). Table 1 presents the mean correct

Table 1. Mean number of facilitation and interference pairs in each mediation category and number of correct responses over 5 trials as a function of Form of the AC List.

Form	Pair	Correct Responses		Mediated		Total	Rate
		F	I	ABC	Other		
Form 1	F	11.00		0.55	2.75	3.20	0.60
	I	8.50		--	2.40	2.40	1.60
Form 2	F	10.45		0.65	2.30	2.95	1.05
	I	9.75		--	3.00	3.00	1.00

anticipations over 5 trials as a function of kind of pair and form of the AC list. On form 1 of the AC list facilitation pairs were learned significantly better than interference pairs, ($p < .01$) but the difference on form 2 did not attain significance ($p > .05$).

For each S, each pair of the AC list was classified as "direct" if S reported to the first series of questions that the response was all that had occurred to him when the stimulus had been presented on the last trial or "indirect" if S reported any intervening activity before the response occurred. Each pair was further classified as "ABC-mediated" if S reported learning it by the use of the ABC sequence; as "other" mediated if by any kind of associative aid; or "rote" if S reported only memorization, repetition, etc. In a mixed analysis of variance (Criterion, Sex, List Form, Kind of Pair) on the number of pairs reported as "direct," the only effect to reach significance was Criterion ($F = 15.745$, $df = 1/32$, $p < .001$) indicating that more pairs were reported as direct in the overlearning condition. The mean number of pairs reported as direct in the two perfect criterion group was 4.35 and in the overlearning group was 6.55. These results are consistent with the notion that post-criterion practice produces a decrease in mediational activity.

Table 1 contains the mean number of facilitation and interference pairs in each mediation category. An analysis of variance on the number of pairs reported as mediated yielded significant effects due to Kind of Pair ($F = 6.427$, $df = 1/32$, $p < .05$) and the interaction, List Form by Kind of Pair ($F = 8.208$, $df = 1/32$, $p < .01$). Only on form 1 were a significantly ($p < .001$) greater number of facilitation pairs reported as mediated, this being the same form on which there was better learning of facilitation pairs. In an analysis of variance on the number of facilitation pairs reported as ABC or Other, only the difference between ABC and other categories reached significance ($F = 43.595$, $df = 1/32$, $p < .001$).

One method of testing for "unconscious" mediation is to compare the learning rate for facilitation and interference pairs as a function of mediation category. Several problems arise with these comparisons, the most important of which would seem to involve the necessity for all kinds of categories to occur in a given S for both facilitation and interference pairs. Eight females and 11 males reported mediated (ABC or other) and rote learning in both facilitation and interference pairs. An analysis of variance (Sex, Kind of Pair, Mediation Category) on the mean correct response per pair per trial yielded significant effects due to Mediation Category ($F = 4.792$, $df = 1/17$, $p < .05$), a higher rate of learning occurring for the mediated than for the rote pairs. The mean correct anticipations per pair per trial for pairs reported as mediated was .714, and for pairs reported as rote was .610. Although

Table 2. Mean correct response per pair per trial as a function of kind of reported mediation

Pair	ABC	Other	Total Med	Rote
Facilitation	.764	.735	.735	.673
Interference		.667	.667	.564

the effect of Kind of Pair did not reach significance, the possibility still might be raised that within the pairs verbalized as rote, facilitation pairs were learned at a faster rate than interference pairs, thus indicating some sort of unconscious facilitation by the ABC chain. However, the difference in learning rate between facilitation and interference pairs did not approach significance either when both were reported as rote ($t = 1.034$, $df = 18$) or when both were reported as mediated ($t < 1$). Since only half of the Ss were used in these comparisons, the mean overall learning rate of facilitation and interference pairs for each Mediation Category was determined on the basis of all Ss who used the category. These data are presented in Table 2 and corresponds generally to the data obtained from the 19 Ss.

Although these results do not support the findings of Bugelski & Scharlock (1952) that facilitation pairs were learned better than interference pairs in the absence of verbalized mediation of the common intervening term, there were several differences between the Bugelski-Scharlock study and the present one. The most important would seem to involve the time interval between the learning of the three lists. Bugelski and Scharlock used a 48-hr. interval while the interval in the present study was only 2 min. Bugelski reported that no S verbalized the common intervening term while 15 Ss in the present study reported using at least one. Another methodological difference may have involved the intervening procedure, the details of which were not reported in the Bugelski-Scharlock study.

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Word association norms: Stability of response and chains of association¹

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Word association norms are reported for 200 boys and girls, aged 12 yr. 9 mos., to 13 yr. 8 mos. For those words which constituted a retest, analysis showed a high consistency in the primary response. When the primaries were used as S words, subjects frequently responded with the word that had originally produced the primary. In 14 cases, however, a new association was produced and these "chains of association" are presented.

The present study reports the results of a word association (WA) test given to eighth grade boys and girls. There were 82 words used in this study. Of these, 35 represent a retest (Shapiro, 1963), and 47 are either primaries (the most frequent response), secondaries (the second most frequent response), or tertiaries (the third most frequent response), selected from the 1963 norms and used in this study as stimulus words. Of interest is a comparison of results obtained in the retest with those of the test given to eighth graders two years previously. Of further interest is a content analysis of responses to those words which were primaries in the earlier study.

Method

A written single association WA test was given to 270 eighth grade boys and girls. It was conducted in the school cafeteria and all Ss took it as a group. Three different orders of words were used and an equal number of booklets in each order was distributed. The words were arranged in two columns, 30 to a page, with each word followed by a line on which the response was to be written. Instructions were read to the group and testing began immediately after. Ss were told to write the first word they thought of when they saw the stimulus word. Ss were urged to work rapidly and, to encourage speed, were instructed to write the time of completion of the test on the back of the booklet.

Of the 270 Ss tested, 200 protocols were selected. Ss were eliminated who were at the extremes of the age range and then Ss were randomly eliminated until 100 boys and 100 girls between the ages of 12 yr. 9 mos. and 13 yr. 8 mos. remained.

Results

The associations for boys and girls were analyzed separately and are available from the author. In addition to a content and frequency analysis of primaries, secondaries, and tertiaries, the number of idiosyncratics and the total number of lexicographic and grammatically different responses are given.

Test-retest comparison. Test-retest comparisons of the responses to the 35 words common to the

earlier test and the present study yielded the following: (a) Identical primaries were recorded in 28 instances for males and 29 instances for females. In every case but one (i.e. "stab" as the primary response to "jab" on the retest for females), those primaries which did change had become the secondaries or tertiaries. (b) The absolute frequency of the primary increased on the retest. Mean frequency of the primaries on the test was 40.31 for males and 39.43 for females; the retest frequencies were 45.23 and 47.83. This increase was found to be significant for females ($t=2.2$; $df=160$; $p<.05$) but not for males ($t=1.3$; $df=160$). (c) The relative frequency of the primaries remained substantially the same on the retest. The Pearson coefficient of correlation for test-retest on frequency of the primaries was .71 for males and .62 for females.

Associations to primaries. WA were obtained for 32 words which had been found to be primaries of stimulus words in the earlier test. Of interest was the use of the resultant norms to develop chains of association. The

Table 1. Chains of Primary Associations: Words in II are Primaries of I. Words in III are Primaries of II

I	II	III
DIM ← .37 ^a ← .10	LIGHT .40 →	DARK (.15) ^b
FUR ← .51 → ← .13	COAT .25 →	HAT (.00)
GAY ← .52 → ← .30	HAPPY .46 →	SAD (.19)
HIT ← .20 → ← .07	BALL .20 →	BAT (.05)
HUT ← .46 → ← .06	HOUSE .26 →	HOME (.02)
JAB ← .19 → ← .03	KNIFE .26 →	CUT (.01)
LUG ← .28 → ← .01	CARRY .20 →	HOLD (.01)
MAY ← .20 → ← .09	MONTH .33 →	YEAR (.00)
MOW ← .33 → ← .21	LAWN .38 →	GRASS (.10)
NOT ← .21 → ← .04	NO .80 →	YES (.07)
PAY ← .53 → ← .12	MONEY .16 →	DOLLAR(S) (.00)
RAW ← .39 → ← .08	MEAT .17 →	STEAK (.01)
RIB ← .30 → ← .10	BONE .44 →	DOG (.00)
WAG ← .57 → ← .11	TAIL .34 →	DOG(S) (.14)

a. See text for explanation of figures

b. p of words in III being given as responses to words in I.

associations to 18 of the 32 primaries were reciprocals, i.e., the original stimulus word. For example the primary to "bad" is "good." When "good" is the stimulus word its primary is "bad." Associations to 14 of the words resulted in new words as primaries. Table 1 shows these chains as prepared from the current WA norms. The numbers indicate strength of association as a probability (p) measure. Thus the p of the primary "light" occurring as a response to "dim" is .37; the p of the primary "dark" occurring as a response to "light" is .40. The p of the reciprocal response to "light," i.e. "light-dim" is .10. Finally the p of "dark" being given as a response to "dim" is .15.

Discussion

The stability of normative responses so far as content of the primary is concerned would appear to be upheld. There is some evidence however of increase in the frequency of the primary. Jenkins & Russell (1960) noted this increase in comparing WA norms collected at the University of Minnesota in 1927 and 1952. The increase observed in the present study occurred over a two year period. This increase may be the result of differences in test procedures. The present study emphasized speed and required single associa-

tions. The earlier study was a multiple association test. The Ss had 17 seconds to respond to each word with up to five responses (Shapiro, 1963).

Speed instructions have been shown to increase the tendency to respond with the most popular response (Horton, Marlowe, & Crown, 1963) and may account for the effect noted in this replication.

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Note

1. This research was supported by grant HD 01014-01 from the National Institute of Child Health and Human Development. Appreciation is expressed to Mr. James P. Reynolds, superintendent of schools and Mr. William A. Tully, principal of South Junior High School, Pittsfield, Mass. Author's address: Austen Riggs Center, Stockbridge, Mass.

Comment on The Role of the Intertrial Interval in Serial Learning: A Clarification by Louis G. Lippman and M. Ray Denny

The existence of a primacy effect in continuous serial learning (no ITI) has been substantiated, using a considerable variety of materials and procedures (Eysenck, 1959; Glanzer & Peters, 1962; Breckenridge, Hakes, & Young, 1965; Harcum & Coppage, 1965; Lippman & Denny, 1964). Lippman and Denny have shown that primacy effects occur when S can view an item as first on trial 1 only (our group E_1) but do not occur when the first item is disguised by the presence of four extralist items which precede the "first" item only on the very first trial (our group E_2). In both instances the serial position curves were plotted from the first item of the list, i.e., the first item seen in group E_1 and the fifth seen in group E_2 on trial 1. In this journal, Keppel (1965) appears to regard the results of these two procedures as equivalent: "the continuous-list condition . . . did not produce primacy and recency effects when position curves were plotted from the item appearing first on trial 1. . ." (p. 471). We would like to set the record straight on this count, at least with respect to primacy effects.

Harcum and Coppage (this journal) appear to share a similar interpretation of our results. They assert that because acquisition was terminated after 24 trials (prior to Ss' reaching a perfect trial criterion in groups E_1 and E_2) the primacy effects had insufficient opportunity to develop. Our point here is that primacy effects, conventionally plotted, did show up in the E_1 group even though they were not present in E_2 . And the fact that groups E_1 and E_2 learned at approximately the same rate

is not necessarily contradictory. Lack of facilitation from primacy in the E_1 group is in keeping with the finding that Ss of group E_2 generated their own idiosyncratic primacy effects ("objective first" curves in our study). In other words, primacy can occur within 24 trials and there is nothing inconsistent in the fact that the two groups (E_1 and E_2) learned at the same rate (primacy was really operative for both). Admittedly, there may have been insufficient trials for recency effects to accrue.

Although the presence or absence of dummy items preceding the first trial seems to represent a slight procedural difference, the difference in S's perception of the list (i.e. "first" item or selection of an anchor) appears considerable. In continuous serial learning, S actually sees the first item as first; therefore, an anchor is available for S's use (analogous to an objective standard in end-anchoring). When dummy items precede the first trial, however, the anchor is not clearly present. To use an anchor, S must note the reappearance of a particular syllable or find a syllable which is idiosyncratically meaningful. He can then use this item as his anchor (analogous to a subjective standard in judgment). Thus, we contend, the only appreciable difference between groups in which dummy items are present or absent is the consensus with which Ss select a particular item for an anchor. Such a contention is supported by the "objective first" curves found by Breckenridge et al and by us. These curves suggest that all Ss learn essentially the same way but employ different anchors.

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The effects of overtraining on a reversal and nonreversal shift¹

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Children, 12-13 years old, were given criterion or overtraining on a modified card sorting test, then transferred to a reversal or nonreversal shift. Type of shift was found to be significant, while degree of training had no significant effect. While the results of reversal ease are interpreted in terms of the operation of a dimension-specific mediator, the failure to find an ORE is accounted for in terms of the S's age, motivation, as well as prior experience in learning tasks.

The weight of the published evidence seems to indicate that there is a direct relation between degree of overlearning and the ease of learning a new antagonistic task. It has been shown (Reid, 1953; Pubols, 1956; Capaldi & Stevenson, 1957; Brookshire, Warren, & Ball, 1961; D'Amato & Jagoda, 1961; Mackintosh, 1962; Capaldi, 1963; Mackintosh, 1963) that if rats are overtrained on a simple discrimination problem, they learn the reversal of the discrimination in fewer trials than rats not so overtrained.

One type of explanation offered to explain the ORE (overlearning reversal effect), put forward by Goodwin & Lawrence (1955), suggests that in any discrimination, two learning processes are involved. One would involve the identification of and reaction to a dimension or set of stimuli, and the second would involve the establishment of preferences to stimuli within a set. The better the first process is learned (as a result of overtraining), the more likely the Ss are to keep on responding to the relevant cues after reversal, the less likely they are to respond to irrelevant cues, and the faster they will learn the reversal.

For example, if one group of children is trained to respond to a brightness dimension, various amounts of overtraining being given, and a second group trained on a number dimension, various amounts of overtraining being given, and subsequently the first group reversed on the brightness dimension (reversal), while the second group is made to learn an entirely different discrimination (nonreversal), the Goodwin and Lawrence hypothesis would make the following differential prediction: overtraining will only facilitate the learning of the reversal, while overtraining on the number discrimination will actually hinder the learning of a discrimination in which a number difference is irrelevant—since the more firmly the number dimension is learned, the longer it will take to extinguish, and successful learning of the second discrimination cannot occur until the number dimension is extinguished, and the appropriate dimension learned.

Method

Subjects. The Ss were 48 seventh-grade students ranging in age from 12-13 years, drawn randomly from a Queens' public school.

Apparatus. Cards from the Wisconsin Card Sorting Test were used. All cards differed in color (red vs. green), in figure (cross vs. circle), and in number (one vs. two, Series I; three vs. four, Series II).

Procedure. The Ss were obtained from the classroom and were brought to the testing room. Testing was done individually and began with the general instructions that S was to play a game, the object of which was "to be correct." Each S was then read the following:

You will be shown a series of sets of two cards. One of these cards, and only one, in each of the sets is correct. The idea for you is to find out which one is correct. You must point to the one you feel is correct. Decide as best you can. If you are correct, I will say, "correct;" if not, I'll say, "incorrect."

The design was a 2 by 3 factorial consisting of Reversal (C-RC), Nonreversal (N-RC) shifts, Criterion, 10-overlearning, and 20-overlearning trials. For the C-RC group, Series I involved their learning "red" as the correct response. For the N-RC group, Series I involved their learning "one" as the correct response. The transfer trials (Series II) began, without informing the Ss of the change in the set of cards, after Ss reached the criterion of five consecutive correct responses, after 10 overtraining trials, or after 20 overtraining trials. "Green" was now correct for the C-RC group as well as the N-RC group. There were eight Ss per cell. (See Table 1.)

Results

Mean trials to criterion on Series I and Series II for groups C-RC and N-RC are presented in Table 2. Analysis of variance for independent groups for Series I yielded an F ratio which was not significant.

However, analysis of variance for Series II reveals a significant difference only for the reversal vs. nonreversal shifts ($F = 78.42$, $df = 1/42$, $p < .001$). No signif-

Table 1. Experimental Design

Groups	Series I	Series II
reverse (C-RC)	R1, R1 G1, G2	G3, G4 R3, R4
nonrev. (N-RC)	R1, G1 R2, G2	G3, G4 R3, R4

R1 = cards with one red figure;
G2 = cards with two green figures, etc.

Table 2. Mean Number Trials to Criterion

	Series I			Series II		
	Crit.	10 ov.	20 ov.	Crit.	10 ov.	20 ov.
C-RC	3.75	4.25	3.50	1.25	1.375	1.125
N-RC	3.50	3.375	3.75	7.25	10.75	9.125

icant interaction effect between degree of training and type of transfer task was found, nor were any differences found in the effect of degree of training.

Discussion

Regarding the hypothesis that in learning a discrimination two processes are involved, the results are in agreement with Goodwin and Lawrence, as well as the findings of Furth & Youniss (1964). The relative ease of mastering the reversal as well as the difficulty experienced in mastering the nonreversal, irrespective of the degree of training, indicates the operation of a dimension-specific mediator. When presented with novel stimuli (Series II), all Ss proceeded to respond along the dimension of their previously established associations.

However, consistent with the results and the interpretation of Stevenson & Weir (1959), the failure to find performance differences according to degree of training may very easily be attributed to the type of S used. On the basis of prior experience, bright children may very well have learned that regardless of the number of times they have been reinforced, withdrawal of reinforcement should be followed by an attempt to find other solutions. Further, since motivation was kept high throughout the experiment, as all children appeared to enjoy the task, it may be

hypothesized that overtraining reduces effectiveness of performance when it results in monotony and decreased drive. Keeping motivation high would seem to reduce the effects of overtraining.

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Note

1. The author is grateful to Dr. William F. Reynolds for his suggestions and criticisms.

Continued from page 234.

Harcum and Coppage (p. 572) also state that we believe an intertrial gap is necessary for the serial position effect. This is not our view despite the title and emphasis of our report. Our discussion about the difference between E_1 and E_2 with respect to primacy and the presence of idiosyncratic primacy effects in E_2 would make no sense if this were the case. The intertrial interval only serves, after the first trial, to enhance the discriminability of the ends of the list.

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Visual preference in the four-month old infant¹

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Four series of stimuli, varying in shape, or color, or in both dimensions, were presented according to the method of pair comparisons to separate groups of infants four months of age. Preference was measured in terms of relative visual fixation time. The shapes used differed in number of turns, area and contour being held constant, and hue, brightness and saturation were specified in Munsell coordinates. Little evidence was found for preference of one color to another, although there were indications that red and blue stimuli were preferred to a grey stimulus of the same shape. There was no demonstrated preference for any of the five regular polygonal shapes used. Where both shape and color were varied within a stimulus set, the ordering suggested dominance of choice by color.

In a previous study of the visual preference behavior of four-month-old infants, Spears (1964) found that, as measured by relative visual fixation time, red and blue stimuli were preferred to a similarly shaped grey stimulus, certain shapes or patterns were preferred to others, and shape dominated color as the basis for preference when members of a stimulus set varied in both color and shape. No completely consistent relation was obtained between the preference orderings for shape and amount of complexity, as defined by the amount of contour or the number of turns, or degree of symmetry, contour, however, being most consistent in this respect.

The present study was an attempt to evaluate the effects of varying the number of turns in a set of shapes, this variable, according to Attneave, being correlated with judgments of complexity (1957). Color, and area and contour, insofar as possible, were held constant. The five regular polygonal figures used—triangle, square, pentagon, hexagon and circle—necessarily varied in symmetry as well as in complexity. Each of the experimental groups viewed a different stimulus series, the stimuli being presented according to the method of pair comparisons and varying in shape, or color, or in both dimensions simultaneously. The four groups, designated by dimension (s) varied as Color (C), Shape (S), Shape-Color 1 (SC1) and Shape-Color 2 (SC2), were each made up of 10 infants around four months of age. About half of the Ss were obtained from a "Well-Baby Clinic" in Denver, the remainder from private homes and a nearby Catholic orphanage, the latter agency contributing about a half-dozen. The median age for all groups was approximately 145 days, the range being from 99 to 157 days.

Method

A cubical box, with interior surfaces finished in

flat black, permitted the Ss to view pairs of stimulus cards at a distance of about 12 in. and O, by means of a one-way viewing screen, to observe and record the occurrences and duration of visual fixation of the pair components. Two Standard Electric clocks (time indicated to 1/100 sec.) were activated by separate pressure switches to accumulate time of fixation. Two fluorescent lamps (G.E. F14T12/CWX), mounted vertically and one to each side of the inner front side of the box, and baffled to prevent direct light from falling upon S, provided about 80 foot-candles of illumination at the stimuli, as determined by a G.E. 213 light meter. Room illumination was approximately 5 to 10 foot-candles. An experimental session consisted of 10 presentation trials of 15 sec. each, the beginning and ending of a trial being signalled by onset and offset of a signal light visible only to O. Accumulated clock readings were recorded to the nearest quarter second and stimuli changed during the 30 sec. intertrial period.

All stimulus cards had a base of white matte board 6 by 4-3/4 in., and a viewable area of 4-3/4 by 4-3/4 in. A stimulus set for each group consisted of five cards which produced the 10 different pair-combinations seen by the group. Those for the Color group each consisted of two concentric circular rings, cut from one of the following Munsell papers: red 5R 5/6, blue 5B 5/6, green 5G 5/6, yellow 5Y 5/6 and grey N/5. The Shape group viewed the combinations possible for the five polygonal figures, constructed like those of the Color group but all in Munsell paper 5R 4/12. Areas for the Shape stimuli were all about 7 sq. in. with contour ranging from 34 in. for the triangle to 38 in. for the circle. Areas and contours for the shapes used for SC1 and SC2 were similarly restricted. The former set was made up of two hexagonal shapes in 5R 5/6 and 5B 5/6 and three square shapes in the same colors and N/5 grey. For SC2, the two hexagonal shapes were in blue and grey and the three squares as in SC1. Letters were randomly assigned to the backs of the cards to permit "blind" selection by O in accordance with a pre-determined order of pair presentation. This sequence was chosen to minimize "time" and "space" errors and is that recommended by Ross (1939) as optimal in these respects. Odd-numbered Ss were given the sequence in one direction and even-numbered Ss the converse of that, with positions of pair components relative to each other reversed.

There were no major differences in the procedures used in the present and the earlier study. The infant having been positioned and seated on the supporting

table with body and head facing the viewing opening and legs and feet extending into it, the viewing lights were turned on and the first pair of stimuli exposed by opening the viewing doors. At the end of 15 sec. the doors were closed for the 30 sec. intertrial period, with subsequent trials being administered in the same manner.

Results

Orderings based on the number of Ss preferring one member of a pair to another and over the 10 possible combinations in a set of stimuli are as follows: C group: Blue = Red > Green > Yellow > Grey; Shape group: Hex = Pent = Tri > Cir > Sq; SC1: Blue Hex = Red Hex > Blue Sq > Red Sq > Grey Sq; and SC2: Red Hex > Blue Sq > Red Sq > Grey Sq > Grey Hex. Significant differences in preference for given stimuli, as evaluated by the sign test, and with 10 Ss, would be at the .02 and .002 level, according to whether 9 or 10 Ss preferred one member or another of a pair. The C and S groups produced no significant preferences and the SC1 group only one, the Red Hex over Grey Sq. SC2 produced four significant preferences, all at the .02 level, and as follows: Red and Blue Sq and Red Hex over Grey Sq, and Blue Sq over Grey Hex. Possible position bias was assessed in terms of *t* values based on differences for each S in a group in total time of fixation to the left and right. That for CS1 was significant at the .05 level.

The individual consistency of each S was computed on the basis of the presence or absence of circular triads (Kendall, 1955), coefficients of 1.00 being needed to indicate true ranking. Only two Ss in CS1 and four in CS2 produced such coefficients. Group agreement, as measured by the Kendall *u*, was significant at the .01 level for CS2 and the ordering of stimuli by that group can therefore be considered meaningful, at least as to preference order of stimuli in that set.

Discussion

As in the earlier study, there is little evidence for preference of one color to another. There is some evidence, particularly in the SC2 group, that colors, in this case red and blue, are preferred to grey. The position bias noted for SC1 may have washed out similar preferences in that group.

The lack of preference ordering obtained with the Shape group was disappointing and made it necessary to assign shapes to SC1 and SC2 on an arbitrary basis. Whether this may have led to the overall lack of significant or consistent results in these two groups is of course a matter of speculation. Only the SC2 subjects agreed significantly as to ordering of stimuli and here color seemed to govern choice. This is contrary

to findings obtained with the SC1 group in the earlier study. There, the two shapes (bullseye and diagonal) and two colors (red and grey) used to make up the stimuli had been shown to differ significantly as regards preference and the ranking definitely indicated shape dominance. In a second group, however, SC2, the shapes used were a hexagonal and bullseye, and the colors, yellow and blue. These, for rational and empirical reasons, were presumed to offer a more difficult discriminative and preference problem, and, in fact, no significant preferences or ranking were found. Huang (1945), it may be noted, reported that the dominance of form or color was apparently related to the extent of dimensional difference obtaining in one or the other dimension.

The tendency to color dominance found in the present study may be the result, then, of the demonstrated lack of preference (and perhaps, discrimination) for the shapes used and the use of these shapes with colors, blue and red, which have generally been found to be preferred to a grey of equal brightness. If complexity is in fact related to the number of turns or angles in a figure, it would not appear to have been effective with the stimuli used. Symmetry would seem to have been equally ineffective. Perhaps, as Attneave suggests with respect to complexity, no single dimension or factor will be completely determinative of preference. If, as Birkhoff proposes (1933), preference is determined by the ratio of order and complexity, we may have to consider whether the stimuli in the present study possibly presented ratios sufficiently equivalent to inhibit preferential behavior.

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Notes

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Predicting interpersonal attraction toward strangers presented in three different stimulus modes¹

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Attraction toward a stranger is a positive linear function of the proportion of his responses to an attitude scale which are similar to those of the S. Though various experimenters have utilized different stimulus modes for presenting the stranger, the effects of such stimulus differences have not been systematically compared nor has the linear function been demonstrated to be generalized across conditions. Ss were assigned to one of three experimental conditions in which a stranger was either depicted in a sound 8mm color movie, recorded on tape, or represented by responses on a mimeographed attitude scale. After learning 12 of the stranger's opinions, Ss were asked to evaluate him. In all three stimulus modes, attraction was found to be a function of proportion of similar attitudes, with no significant differences attributable to conditions. A straight-line function was fitted to the data, yielding the formula $Y = 6.74X + 5.06$. This finding adds to the generality of the attitude-attraction relationship and also provides a methodological improvement.

With data obtained in relatively specific stimulus conditions, Byrne & Nelson (1965) found that attraction toward a stranger is a positive linear function of the proportion of his responses on an attitude scale which are similar to those of the S. These data were drawn from studies employing a total of 790 Ss who had examined an attitude scale purportedly filled out by a stranger. It was proposed that this linear function is a general one, but the possibility remained that it is dependent on that specific method of presenting the stimulus person.

In other experimental investigations of interpersonal attraction, the stimulus person utilized to elicit attraction responses has been presented in a variety of ways. For example, Ss have been asked to respond to another individual who is actually a stooge (Aronson & Linder, 1965), who is depicted in a specially prepared motion picture (Altrocchi, 1959), whose photograph is shown to the S (Byrne & McGraw, 1964), and whose voice has been recorded on tape (Jones, 1965). The possible influence of mode of presentation on attraction has not been investigated. It is possible, for example, that as the number of available cues (e.g., voice quality, attractiveness, accent) increases, the prediction of attraction on the basis of attitude similarity becomes progressively less accurate.

In the present investigation, the generality of the relationship between attitude similarity and attraction across stimulus modes is determined. Specifically, the functional relationship between proportion of similar

attitudes and attraction is examined under three different conditions of stimulus presentation: a color movie with sound track, a tape recording, and written responses on a mimeographed attitude scale.

Method

The Ss consisted of 120 introductory psychology students (60 males, 60 females) at the University of Texas. Each was randomly assigned to one of three experimental conditions in which small groups of Ss were asked to fill out a 12-item Survey of Attitudes dealing with such varied topics as racial integration, political parties, and classical music. Afterward, the Ss were told that the experiment dealt with the accuracy of interpersonal judgments. They would be given the opportunity to learn something about another undergraduate student and then would be asked to make judgments about that person's intelligence, knowledge of current events, morality, and adjustment and also to indicate how much they believed they would like the person and how much they would like to work with him or her. The latter two items, each consisting of a seven-point scale, are added to provide the measure of the dependent variable which ranges from 2 to 14 points (Byrne & Nelson, 1965).

In each experimental condition, the "stranger" (the same sex as the S) responded with one of two standard patterns of attitude responses in order to control for the possible effects of specific content. In the movie condition, one male and one female each made two sound 8 mm color movies (A and B patterns) in which they expressed their opinions on each of the 12 topics. In the tape recording condition, the assistants each made two recordings identical to the movie sound tracks. In the mimeograph condition, faked attitude scale responses were devised following either pattern A or B.

Results

The similarity between any given S and the stranger to whom he was exposed could vary from 0 to 12 (.00 to 1.00 similar attitudes); in the present sample the actual variation was from 1 to 10 (.08 to .83 similar attitudes). A three by four factorial analysis of variance was carried out. Attitude similarity was found to have a highly significant effect on attraction ($F = 11.20$, $df = 3/108$, $p < .001$), but neither the effect of the three stimulus modes nor of the interaction were statistically significant.

Combining the data for all 120 Ss, the relationship between proportion of similar attitudes and attraction was plotted as shown in Fig. 1. A straight-line function

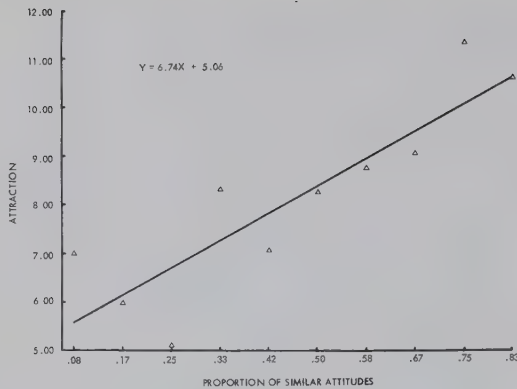


Fig. 1. Attraction toward a stranger as a linear function of proportion of similar attitudes with movie, tape recording, and mimeograph conditions combined.

was fitted to the data by the least squares method; the solution yielded the formula $Y = 6.74X + 5.06$. Thus, the linear relationship between attitude similarity and attraction is once again found even though the mode of stimulus presentation is altered.

It should be noted that the specific m and k values for the present data differ from those reported by Byrne and Nelson ($Y = 5.44X + 6.62$). By a goodness of fit analysis, a significant difference was found between the Byrne-Nelson line and the present data ($F = 4.09$, $df = 10/110$, $p < .01$). Specifically, the linear function depicted in Fig. 1 has greater slope and a lower Y intercept than the previously reported one. It is possible that these differences are a function of the much shorter time period between response to the attitude scale and response to the stranger in the present design.

Discussion

The law of attraction (Byrne & Nelson, 1965) states that attraction toward X is a positive linear function of the proportion of positive reinforcements received from X ; similar and dissimilar attitude statements are interpreted simply as special instances of positive and negative reinforcement (Golightly & Byrne, 1964). This linear function has now been found to hold not only with respect to attitude similarity but for similar

and dissimilar economic status (Byrne, Clore, & Worchel, in press), responses to items of fact concerning both past and future events (Byrne, Nelson, & Reeves, in press), evaluative statements concerning the subject (Byrne & Rhamey, 1965), ratings of the originality of the subject's creative productions (McDonald, 1962), and responses given by the experimenter in a learning situation (Golightly, 1965).

Further, it appears that the effect of attitude similarity on attraction is not limited to any specific method of presenting the stimulus person. It should also be noted that methodologically, the present research design makes it easier to investigate the effects of other variables on the relationship between similarity and attraction. Rather than a two-step procedure in which a bogus stranger is laboriously constructed for each subject, attraction may be investigated in a single setting with "standard strangers."

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Note

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OKLAHOMA STATE UNIVERSITY

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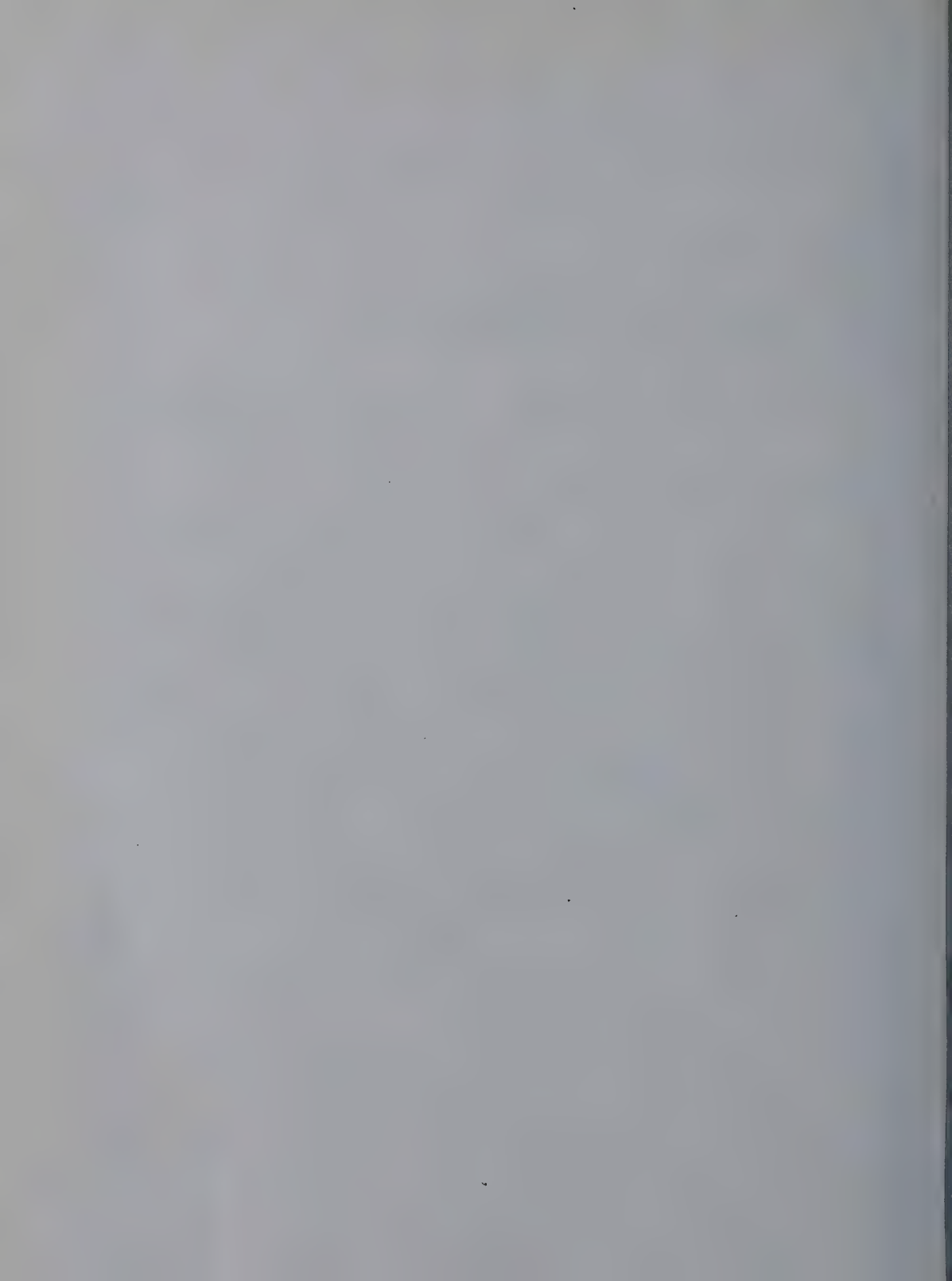
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Waning of aggressive motivation in *Betta splendens*

RONALD BAENNINGER

THE JOHNS HOPKINS UNIVERSITY

Siamese fighting fish showed a waning tendency to view both their own reflections and a similar fish during trials lasting 32 hr. Although both stimuli elicited aggressive displays, all Ss spent more time viewing their reflections than viewing the live stimulus fish.

Recent experiments have shown that the opportunity to perform an aggressive display may serve as reinforcement in the acquisition of operant responses (Thompson, 1963; Thompson, 1964). The possibility exists that the demonstrated "extinction" of these responses is due to a waning tendency to approach stimuli which elicit aggressive displays, or even to avoidance of such stimuli. Clayton has shown that repeated elicitation of the aggressive display itself results in its habituation.¹

In the present experiment the position preferences of Siamese fighting fish (*Betta splendens*) were observed individually as a function of time in a 3-alternative choice situation. Position of the S was assumed to represent a choice among three portions of a rectangular tank, at one end of which was a mirror. At the opposite end was another betta in a separate tank; no stimuli were visible to the S in the center portion of the experimental tank. Position of the S was studied since such data could give evidence regarding approach or avoidance responses to the stimuli, both of which are capable of eliciting vigorous aggressive displays.

Subjects

Ss were five naive male Siamese fighting fish. The stimulus fish was another betta which had been habituated to his reflection in a mirror so that he displayed only briefly at the beginning of each trial. All fish were approximately the same size and color.

Apparatus

The rectangular experimental tank measured 4-1/2 x 18 x 6 in., and was made of clear Plexiglas. The small tank for the stimulus fish was clear glass and measured 3 x 4 x 6 in.

Procedure

Each S spent 32 consecutive hours in the main tank in two conditions. In the Control condition, neither the mirror nor the stimulus fish was present at the ends of the main tank. A trial began when a S was placed at the midpoint of the main tank. Observations lasting 15 min. were made initially and at 1, 2, 4, 8, 16, and 32 hr. thereafter, after which the S was removed and fed. In the Experimental condition, which began 16 hr. after the end of the Control condition, the mirror and stimulus fish were present at the tank ends. In all other respects the procedure was identical to the Control

condition. The amount of time during which the S's anterior end (as far back as its gill membrane slits) was in each portion of the tank was recorded during 15-min. observation periods.

When not in the main tank fish were housed in individual round jars surrounded by opaque material, and were fed only in these jars. Water temperature remained at 72°F., and illumination was provided by a 40 watt bulb 2 ft. above the center of the main tank.

Results

The principal results are shown in Fig. 1 where mean time spent in the center portion of the tank ("center time") during each observation period is plotted against $\log_2$ of the time in hours following the beginning of each trial. Each data point represents the mean of five fish. A trend test was performed on these means by computing the correlation coefficient between number of the observation period and mean center time for that observation period. In the Control condition there was no significant correlation, but the upward trend in the Experimental condition was significant ($r=0.78$; $p < 0.05$).

In order to see whether the variability of the data observed obscured the upward trend, the Fisher exact-probability test was applied to the center time data in the following way. The grand mean of all Ss and observations was calculated for each condition. The number of scores falling above and below this mean in the first three and in the last three observation periods of the relevant condition were found and entered in a 2 by 2 table. A trend in a condition between the first

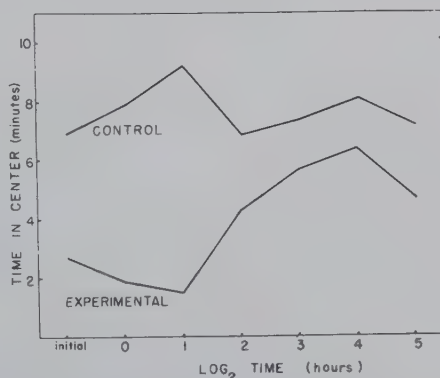


Fig. 1. Mean time spent in center portion of tank during observations of 15 min. duration. In the Experimental condition stimuli were present in the ends of the tank but not visible from the center portion. In the Control condition no stimuli were present.

three and last three observation periods would thus be indicated by a change in the distribution of scores above and below the mean. The Fisher test indicated a significant trend for the Experimental condition ($p=0.02$); the trend was not significant in the Control ($p=0.22$) supporting the above finding of a trend in the Experimental condition only.

The data on amount of time spent in front of both the mirror and the stimulus fish were analyzed, but no significant trends at either end were found in either condition. Thus, the increased preference for the center of the tank, which was found in the last three Experimental observations, did not result from consistent trends in the time spent at either end.

During the Control condition all Ss showed a bias toward the ends of the tank, making the trend toward the center in the Experimental condition more marked. Since the center portion made up two-thirds of the tank volume a mean of 10 min. out of 15 would be expected for center time if all positions were equally likely. Only one S spent this much time in the center during the entire Control condition, and the amount of time spent in each end of the tank remained approximately constant and equal, for each S.

Regardless of which end of the tank they went to initially in the Experimental condition, all fish spent more total time during seven observations in front of the mirror than in front of the fish. The ratio of total "mirror time" to "fish time" was nearly three to one. All Ss exhibited this pronounced preference for their own reflection over the sight of the real betta, although no qualitative differences in response to the two stimuli were noted.

Discussion

It seems clear that in the Experimental condition fish spent an increasing proportion of their time out of sight of the stimuli which elicited aggressive displays. This changing preference cannot be considered avoidance, since the center time in the Experimental condition was never significantly greater than in the Control condition, but the result does indicate a decreasing tendency to view stimuli which elicit aggressive displays. It appears that the reinforcing properties of such stimuli may exist for a limited time only, and that the extinction reported by Thompson may be due to this decreased tendency to approach mirrors and stimulus fish. Longer trials might show avoidance of these stimuli, but confounding with food deprivation effects or fatigue would be likely. In the later observations two fish were observed to swim rapidly away from the mirror whenever they caught sight of their reflections. Very few displays were noted during the last three observation periods, compared to initial continuous displaying by all subjects. This finding suggests that habituation of the display itself was occurring, and supports the more exact findings of Clayton. It thus appears that the tendency to approach stimuli which elicit the aggressive display, and the display itself, are subject to habituation.

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Note

1. F. L. Clayton, Personal communication (1965).

Errata

THOMPSON, R. F., DENNEY, DUANE, & SMITH, H. E. Cortical control of specific and nonspecific sensory projections to the cerebral cortex. *Psychon. Sci.*, 1966, 4(3), 93-94.—The second author's name should be spelled both on the cover and in the article itself as Denney (not Denny).

FRANK, R., & KENYON, J. Visual cliff behavior of mice as a function of genetic differences in eye characteristics. *Psychon. Sci.*, 1966, 4(1), 35-36.—The second author's name is Kenyon, not Kenton. Line 7 of the first paragraph after the abstract should read "... whether a selective breeding process ... "not "a type of." In the paragraph following, line 6 should read "... effects of type of breeding," not "selective breeding."

Spontaneous alternation and middle ear disease¹

ROBERT J. DOUGLAS
STANFORD UNIVERSITY

Rats with middle ear disease and control Ss from the same population with the same history were tested for spontaneous alternation in the T maze, with and without the presence of odor trail cues. The results indicated that the middle ear group had a normal odor trail avoidance tendency but entirely lacked alternation when these cues were removed. These results support the hypothesis that spontaneous alternation is a combination of odor trail avoidance and spatial direction alternation, with the latter tendency being based on vestibular information.

The term "spontaneous alternation" refers to the tendency of the rat to make alternate responses at the choice point of a T maze on two consecutive unrewarded trials (see Dember & Fowler, 1958). From the results of experimental manipulation, using intact rats, Douglas (1964) concluded that spontaneous alternation is the result of the addition of two independent factors. The more important of these is a tendency to turn in opposite spatial directions at the choice point, and the weaker factor is a tendency to avoid the odor trail from the first trial. Elimination of either odor trail or the opportunity to make turns in opposite spatial directions resulted in a reduced alternation rate, while removal of both entirely eliminated alternation. It was found that rats do not "compensate" for the loss of one factor by increasing alternation to another one. The present study was undertaken as a verification of those findings through the observation of alternation in rats with middle ear disease, a condition which profoundly disrupts the vestibular system. It was assumed that the vestibular system must be necessary for spatial direction alternation, but irrelevant as far as odor trail avoidance is concerned. If this assumption is true, then rats with vestibular disturbances should retain their odor trail avoidance tendency but have a greatly reduced tendency to turn in opposite spatial directions. The following procedure was used to test this assertion.

METHOD

Subjects

All Ss had previously been used in barpress studies, but at least 1 mo. had elapsed since the last test. All were male rats weighing between 350 and 400 gm, and were individually housed, with food and water *ad lib*. Six Ss were made available to the experimenter upon the detection of middle ear disease, along with six control animals from the same original source, and with the same histories in the lab. Middle ear disease was diagnosed by the presence of a chronic tilt of the head and a powerful tendency to twist when held by the tail. There is no ambiguity in this test, as the condition

is unmistakable. Since vestibular disturbances were judged on the basis of behavior, the brains were not examined in detail histologically. Gross dissection of one S revealed a pus-filled degeneration of the region of the middle and inner ear on one side.

Apparatus

A T maze of the following dimensions was used: Main and cross alleys were 16 in. long, 4 in. wide, and 5 in. high. The first 6 in. of the main alley was used as a start box, and was separated from the rest of the maze by a sliding door. Sliding doors were also located at the entrances to the side alleys. The maze was covered with wire mesh, but did not have a built-in floor. The maze was placed directly over a piece of heavy opaque paper which was placed on top of a table. Illumination was provided by overhead fluorescent lights.

Procedure

All Ss were first tested with odor trail cues present, or with the same paper floor used on all trials in a session. The paper was changed between sessions and Ss. Following this, odor trail cues were eliminated by changing the paper floor between each trial. Only three pairs of Ss were available for this second test because the others had been prematurely disposed of through a misunderstanding of instructions. On the first test S was placed in the start box and, after a 10 sec. wait, the door to the main alley was raised. When S's whole body was present in one of the side alleys, the door to that alley was lowered and the response scored. After 10 sec. in the side alley, S was removed and replaced in the start box for the next trial. Ss were given consecutive trials until their response latency was 1 min. or more, or until 11 trials had been run. At this point Ss were returned to their home cages until the next day. This procedure was repeated until each S had 25 opportunities to alternate the response of an immediately preceding trial, with the time interval between successive responses being always less than 1 min.

Three days after completion of the first test, alternation was tested with odor trail cues removed. The procedure was similar to that above except that a new paper floor was used for each trial, with S being gently placed in a cardboard box for the few seconds required for the change. Ss were given only 15 opportunities to alternate in this condition, as both groups were becoming maze resistant. Each S was given a total score under both conditions, and data were also analyzed by trials and days.

RESULTS

Ss with middle ear disease were found to alternate at a mean rate of 60.7% when odor trail cues were present,

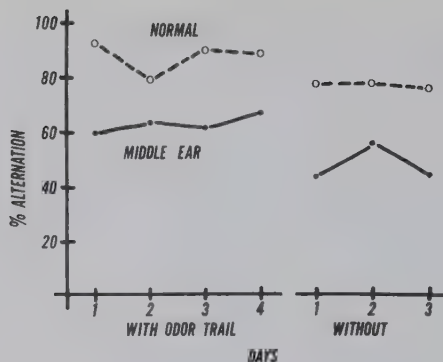


Fig. 1. Alternation over daily sessions with and without odor trail cues.

while the normals alternated at a much higher rate of 86.3% ($t=6.6$, $p<.001$). The middle ear rate was, however, significantly above a chance 50% ($t=2.8$, $p<.05$), and was very close to that reported by Douglas (1964) for odor trial avoidance (middle to low 60s). The middle ear Ss tended to make more responses per session, but the difference was not significant. There was no detectable relation between scores obtained on longer and shorter sequences, and differences between days were negligible, as can be seen in Fig. 1.

When odor trail cues were eliminated alternation in the middle ear Ss dropped abruptly to a mean of 45.3%, which does not differ from a chance 50%. This rate was significantly lower than that of the normals' 75.3%

($t=4.0$, $p<.02$). The drop in performance in the middle ear group was also significant, despite the small number of Ss ($t=3.1$, $p<.05$, 1 tail). These results are shown in Fig. 1.

DISCUSSION

These results are in close agreement with the findings of Douglas (1964) which were discussed earlier, and all of these figures are comparable to his. These results suggest that middle ear disease does not merely disrupt behavior in general, as these Ss appeared to retain normal odor trail avoidance tendencies.

It was suspected that this test might prove to be invalid because of the possibility that the middle ear rats might tend to turn preferentially in the direction of head tilt, or to "bank" around the turn. This did not prove to be the case, however, as the three animals with heads tilted to the right made almost the same number of right turns as did those with heads tilted to the left, with the total tendency to turn in the direction of head tilt being only 54.3% on the initial trials. Thus, the present results are not due to a turn bias, and are more probably due to a lack of spatial direction alternation due to a disturbance of the vestibular system.

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Note

1. This study supported in part by a fellowship to the author from the department of Health, Education, and Welfare: MH 23,382-02.

Influence of overlearning on single habit reversal in naive rhesus monkeys¹

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Naive rhesus monkeys, trained to a criterion on a visual discrimination task, were given reversal trials on the same problem after either 6 or 126 additional trials. The two groups did not differ in visual performance as would have been predicted by the overlearning reversal effect. This failure is not easily attributable to procedural variation which has been present in previous primate studies, and it suggests the possibility of phylogenetic differences in habit reversal problems.

Recent investigations with monkeys (Boyer & Cross, 1965; Cross & Brown, 1965; Cross et al, 1964) and with preschool children (Vaughter & Cross, 1965) have failed to show the overlearning reversal effect (ORE), i.e., more rapid habit reversal following overtraining. While negative findings are not unique even in ORE studies with rats (D'Amato & Schiff, 1964; Paul, 1965), the primate studies in which the ORE has failed to occur have differed procedurally from the rat studies to the extent that comparability is questionable. In one of the primate studies (Cross et al, 1964) initial training was greatly extended, but even the results of this investigation may not have been definitive because the number of reversal trials was smaller than typically found in rat studies and each S received several successive reversal problems. Accordingly, the present brightness discrimination experiment with primates was designed to approximate the procedure of previous tests of ORE with rodents.

Method

Ss were 14 experimentally naive male rhesus monkeys, 4-5 years of age. Pretraining consisted of adapting Ss to the WGTA and training them in short daily sessions to displace a single unpainted block covering a baited foodwell. The WGTA with a conventional formboard was used. Stimuli were two 3 x 3 x 3/4-in. blocks, one painted grey and one white, and each was readily discriminable from the aluminum-colored formboard.

Pretrained Ss were randomly divided into two groups of seven Ss each. One group was designated the criterion learning (CL) group and the other the overlearning (OL) group. All Ss were run 24 noncorrection trials per day on the same brightness discrimination problem. The initially nonpreferred block was rewarded (raisins) until the criterion of 20 correct out of 24 successive trials, with the last six responses correct, was obtained. Rewarded position was randomized, but balanced over 24 daily trials. The Ss were given continuous daily testing until the criterion was met.

In the session after reaching criterion Ss in Group CL received six additional trials on the original problem, and immediately thereafter they were given the reversal problem under the same procedure and criterion as was used in the original problem. When Ss in Group OL met criterion, they were given 120 postcriterion trials on the original problem (five additional days) before receiving the same reversal problem as did Ss in Group CL. Both groups received the reversal problem for at least six consecutive days, even though some Ss had met criterion earlier.

Results

The mean trials-to-criterion (TTC) scores for the original discrimination were 75.43 and 68.57 for Groups CL and OL, respectively. These means were not significantly different ($F = .25$; $df = 1/12$). During the overlearning period Group OL Ss were correct in 98% of their responses, with only 16 incorrect choices in a total of 882 trials.

The mean TTC scores for the reversal problem were 147.43 for Group CL and 106.29 for Group OL. While this difference appears large and is in the appropriate direction to support the ORE, it is largely the result of one aberrant S in Group CL who took 288 trials to reach criterion. Statistical analysis failed to show a significant mean difference ($F = 1.65$; $df = 1/12$; $p < .25$). Mean errors-to-criterion (ETC) scores of 72.14 and 55.86 were obtained by Groups CL and OL, respectively. Statistical analysis of ETC scores also indicated no significant mean difference ($F = 1.19$; $df = 1/12$). Since all Ss were tested on the reversal for at least six days, another two-factor analysis of variance of daily total correct responses was done with the following results: Groups ($F = .48$; $df = 1/12$), Days ($F = 102.41$; $df = 5/60$; $p < .001$) and Groups by Days ($F = 1.54$; $df = 5/60$; $p < .25$).

Discussion

Failure to obtain an ORE in a visual discrimination problem has been reported in two studies with monkey Ss (D'Amato, 1965; Tighe, 1965) after the present research was completed. Since these two studies were procedurally similar to the present investigation and to those in which ORE has previously been reported, the conclusion seems warranted that the discrepant results cannot be attributable simply to procedural differences in previous primate studies. In five experiments using infrahuman primates (Boyer & Cross, 1965; Cross & Brown, 1965; Cross et al, 1964; D'Amato, 1965; Tighe, 1965), and in one with children (Vaughter & Cross, 1965) there has been no evidence

of an ORE. In addition to the problems already under consideration in the ORE area (Mackintosh, 1965; Paul, 1965; Sperling, 1965a, 1965b; Theios & Blosser, 1965), it is likely that an additional one, that of phylogenetic level, will also require attention.

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Comment on Myers et al

by Stanley Weckkin and Gene P. Sackett

Myers, Horel, & Pennypacker (1965) claim to have established operant control over a vocal response (VR) in *Cebus albifrons*. Unfortunately, it is not clear from their report that the VR functioned as an operant, i.e., as an instrumental response, rather than as a respondent. If the VR is one which would ordinarily be elicited by the presence or anticipation of the US, that is, if the VR were a food call, then the association of the VR with the S^D would be a case of classical conditioning. Unfortunately, we know of no published report in which the food call of this species is adequately described. However, the VR used by Myers et al, namely, one with a frequency of 1000-3000 cps and a duration greater than 0.1 sec. is almost identical to a food call of the rhesus (Rowell & Hinde, 1962) and is probably the same as the food call described by Van Hooff (1962) for a large number of species, including *Cebus albifrons*. It has been frequently observed in zoos and laboratories that this type of VR becomes associated with a particular stimulus, e.g., the appearance of the caretaker who does the feeding. However, to call any response associated with a stimulus an operant is to make the term operant so broad as to deprive it of distinctiveness.

This is not to deny that a primate vocalization can come under operant control. However, even if the authors had unequivocally demonstrated this, their conclusion that "the vocal responses of nonhuman animals and humans seem to be acquired and maintained in basically the same way" would still not follow. The proposition that a response can come under operant control is not identical to one stating that the presence of the response in a larger population is also predicated on operating conditioning. Thus for example, Brener (1965) has recently shown

For reply by Pennypacker, Horel and Myers see page 254.

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Notes

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2. Texas Technological College.

that heart rate can come under operant control, but this is very far from saying that heart rate is a behavior acquired through shaping, selective reinforcement, etc.

In the Wisconsin Primate Laboratory monkeys have been reared in complete isolation, where they have no physical, visual, or auditory contact with other species members, and hence where reinforcement contingencies for vocalizations were absent. These animals do vocalize. Observations during the isolation period by one of us (GPS) indicate that isolates produce essentially the same sounds as non-isolates, although with a lower frequency of occurrence. This suggests that few, if any, of the vocalizations of laboratory-reared rhesus monkeys are acquired through conditioning. Furthermore, when isolates were later tested for social behavior some of their vocalizations were "socially appropriate," e.g., cooing under stress, and barking and screeching during aggression. This implies that at least some vocalizations are innate, and depend upon nothing more than appropriate releasing stimuli for evocation and maintenance. Thus, while it may be true that many vocalizations of monkeys can be brought under operant control, this alone does not prove that operant conditioning is either necessary or sufficient for normal development of nonhuman primate vocalization.

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Reversal of an operant discrimination by noncontingent discrimination reversal training¹

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Rats who had received extensive training on a free-operant bar-pressing discrimination were given discrimination reversal training with the bar removed and reinforcements noncontingent, and then were tested on the reversed problem with reinforcements again bar press-contingent. In comparison to control groups that, prior to exposure to the reversed-contingent problem, received either no noncontingent discrimination training or noncontingent discrimination training on the unreversed problem, these Ss showed marked transfer (both immediate transfer and savings) from the noncontingent to the contingent reversal problem. This result is related to previous findings and to several possible theoretical interpretations.

A number of recent studies have shown that the rate of acquisition of a free operant (S^D-S^A) discrimination can be markedly affected by discriminative pretraining conditions which involve S^D and S^A but which do not explicitly involve differential reinforcement of the reference response. For example, Trapold & Odom (1965) showed that Ss who have learned a discrimination with one response (R_1) will subsequently acquire the same discrimination with a second response (R_2) much faster than Ss who are acquiring the discrimination for the first time with R_2 . In that same study, it was also shown that after the same discrimination had been learned with both R_1 and R_2 , discrimination reversal training with R_1 effected virtually complete reversal of the discriminative output of R_2 despite the fact that R_2 had never explicitly been subjected to the reversed discrimination contingency.

In another study (Trapold & Fairlie, 1965) it was shown that noncontingent discrimination training also transferred to a discrimination problem involving the same discriminative stimuli, but with reinforcements now contingent upon a specified response. Indeed, the amount of transfer to R_2 discrimination learning produced by noncontingent training was essentially identical to that produced by discrimination training with reinforcements contingent upon R_1 . In other words, these transfer effects appear to depend only upon the S^D and S^A having been paired with reinforcement and nonreinforcement per se, rather than upon a more response specific process such as response generalization or induction.

The purpose of the present experiment was to extend the observations of the effects of noncontingent discrimination training to the case of discrimination reversal learning. That is, given that Ss have already learned an S^D-S^A discrimination with some response, will noncontingent reversal training (like reversal training with a different response) lead to reversal of the discriminative output of that response?

Method

Ss were 11 male albino rats maintained at 80% of ad lib body weight throughout the experiment by controlled-amount feedings after each daily session. The apparatus consisted of two identical operant conditioning chambers each housed in its own sound-shielding chamber, controlled by programming equipment located in a different room, and containing a retractable response lever, a foodcup into which .045 gm P. J. Noyes food pellets could be delivered, and a houselight that served as the discriminative stimulus.

The basic daily session throughout the experiment consisted of eight 5-min. periods during which the houselight was alternately on and off. During each phase of the experiment, one of these stimulus conditions defined the S^D , the other the S^A . During S^D periods, reinforcements were delivered on a variable interval 1-min. schedule, contingently upon bar-pressing during the response-contingent phases, and noncontingently during the noncontingent phases. Reinforcements were never delivered during S^A under any circumstances.

All Ss had served in a previous experiment in which they had received extensive discrimination training with light-on as S^D and light-off as S^A , and reinforcements contingent upon bar pressing. As a result of this training, Ss were making an average of approximately 85% of their responses in the light-on stimulus condition at the beginning of the present experiment.

The final test phase of the present experiment, lasting seven days, involved a simple reversal of the S^D and S^A with reinforcements continuing to be contingent upon bar pressing. However, prior to that phase, Ss were divided into three groups and subjected to differential treatment.

The noncontingent reversal group (Gp. NC-R, $N=4$) received 40 sessions of noncontingent reversal training. With the bar removed from the chamber, pellets were delivered as described above during the light-off periods and not during the light-on periods. The noncontingent nonreversal group (Gp. NC-NR, $N=4$) was treated identically except that they received noncontingent pellets in the light-on periods and not in the light-off periods. The contingent reversal group (Gp. C-R, $N=3$) was included as a control against which to assess the completeness of any transfer observed in Gp. NC-R. This group received 36 days of response-contingent discrimination reversal training (sufficient to produce asymptotic performance on the reversal problem) followed by four days of noncontingent reversal training. The purpose of this noncontingent reversal training was to control as much as possible for any decremental effects that noncontingent reinforcement might have on subsequent bar pressing performance in Gps. NC-R and NC-NR. Such decremental effects were observed on absolute bar pressing rates in a previous study (Trapold, Myers, & Carlson, 1965), and, while they did not appear to affect relative response output to the discriminative stimuli, it was nonetheless thought desirable to at least partially control for such effects by exposing Gp. C-R to some noncontingent training prior to the test phase.

Results and Discussion

Figure 1 shows the performance of all three groups on all seven test days in terms of the mean proportion of responses emitted in S^D . It also shows the performance of Gp. C-R over the first seven days of its exposure to contingent discrimination reversal training. It is apparent that in comparison to either Gp. NC-NR on the test days or to Gp. C-R on its first seven days of reversal training, the noncontingent reversal training given to Gp. NC-R resulted in considerable facilitation of reversal learning. Not only did Gp. NC-R learn

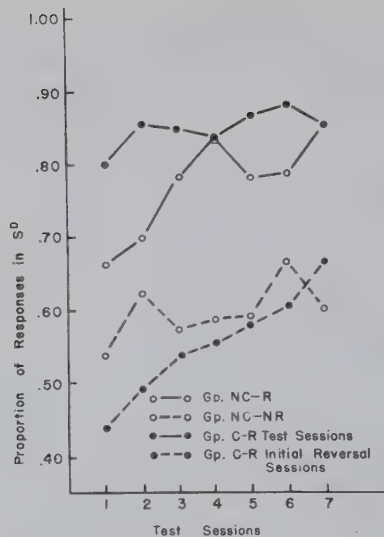


Fig. 1. Mean proportion of responses in S^D per session.

the reversal problem faster, but it also showed a sizeable amount of discriminative responding on the first day.

A repeated measures analysis of variance of Gps. NC-R, NC-NR, and C-R over the seven test days yielded a significant group main effect ($p < .05$) as did a parallel analysis comparing Gps. NC-R and NC-NR with the first seven days of reversal training for Gp. C-R ($p < .01$). Individual pairwise comparisons of the various groups on each test day within these overall analyses showed Gp. NC-R to be significantly ($p < .05$) superior to the initial reversal performance of Gp. C-R on all test days, significantly superior to Gp. NC-NR on test days 3, 4, 5, and 7, and significantly inferior to Gp. C-R on none of the test days.

In short, then, these data support earlier conclusions (Trapold & Odom, 1965; Trapold & Fairlie, 1965; Bower & Grusec, 1964) that (a) the acquisition and reversal of discriminative responding with a given response can be strongly influenced by prior discrimination procedures that do not allow for the differential reinforcement of that response, and (b) noncontingent discrimination training and discrimination training involving a different response are both effective means of facilitating discriminative output of the reference response.

From the standpoint of theory, these data can be most readily interpreted in terms of some form of two-process or mediation theory. In its most general form such a theory assumes that learning such as that studied here is actually based upon two separate learning processes. One process consists of the acquisition of differential strength of tendency (i.e. habit strength) to make the specific instrumental response to the S^D and S^A (or correlated stimulus events) and

is dependent upon the differential reinforcement of that response with respect to these stimulus events. The second process is seen as involving the acquisition of some class of collateral responses, this learning being dependent only upon the temporal pairing of the S^D and S^A with reinforcement and nonreinforcement respectively. It is then assumed that these collateral responses have the capacity to interact with the instrumental response tendency so as to modulate the output of the reference response.

Perhaps the most familiar version of this type of theory for positively reinforced behavior is that proposed by Spence (1956), in which the collateral responses (r_g-s_g) are classically conditioned (based upon the reinforcer acting as the UCS), and are seen as interacting in a motivational fashion with habit strength to produce performance. A plausible alternative to Spence's theory views these r_g 's as sources of stimuli (s_g 's) to which the reference response becomes conditioned (cf. Shapiro & Miller, 1965); still other plausible alternatives can be constructed on the assumption that the collaterals are instrumentally rather than classically conditioned (cf. Trapold & Fairlie, 1965). In the writer's opinion, there is not at the present time sufficient grounds for making a rational choice among these theoretical alternatives. Neither are there sufficient grounds for deciding such questions as (e.g.) whether it will be necessary to assume a collateral process associated with non-reinforcement as well as reinforcement, or the extent to which the collateral processes are specific to a given reinforcer. However, the existence of transfer phenomena such as have been shown here and in previous studies leaves little question that the traditional response-specific uniprocess model of free operant discrimination learning is not sufficient to deal with the currently available facts.

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Note

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Fear conditioning as a function of CS duration during acquisition and suppression tests

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The effects of CS duration during fear conditioning were assessed using a secondary punishing technique. CS duration was not found to be an influencing variable. Inadequacies of the secondary punishment procedure utilized by Mowrer and his colleagues were noted and it was suggested that more extensive comparisons be made of the CER technique with an improved secondary punishing procedure.

In investigating critical parameters of fear conditioning, Mowrer & Aiken (1954) and Mowrer & Solomon (1954) used the technique of conditioned suppression via a secondary punisher. In this procedure a rat is trained to make an operant bar press on a CRF schedule for food. Concurrently, but in a different environment, a CS (light) is presented immediately prior to shock, i.e., a fear conditioning procedure. After several training sessions in each situation, the CS is used as a secondary punisher by being made contingent on the bar press. The fear arousing capacity of the light is inferred from the amount of response suppression which occurs during the secondary punishment phase. This procedure differs from the more widely used conditioned emotion response (CER) procedure (Estes & Skinner, 1941) in that in the CER technique the presentation of feared stimulus is not contingent upon S's response. It is programmed independently of the food reinforcement schedule. The amount of response suppression which occurs while the conditioned stimulus is present is taken as an index of its fear arousing capacity.

Kimble (1961, p. 270) states that "...the function relating strength of fear to the time separating neutral and noxious stimuli resembles that for other classically conditioned responses." However, this generalization has a very limited empirical support being based primarily on studies of avoidance conditioning rather than fear conditioning per se. Those experiments which have studied fear conditioning using a CER procedure have typically found optimal durations to be considerably longer than the .5 sec. which Kimble implies. Libby (1951) found that response suppression increased with increases in CS duration up to 7 sec., but observed no increases between 7 sec. and 30 sec., i.e., the function was a negatively accelerated increasing one which was asymptotic around 7 sec. Using pigeons, Lyon (1963) found that as the CS duration increased from 100 to 300 sec., the amount of suppression increased. Similarly, Stein et al (1958) and Carlton & Didamo (1960) found *relative* CS duration to be an important parameter of conditioned suppression.

The purpose of the present experiment was to determine if similar results would be obtained if the CS

were made response contingent and thus used as a secondary punisher. It seemed reasonable to use, where possible, the same procedures and parametric values which were used in the original experiments by Mowrer and his colleagues, since they had obtained differential response suppression.

Method

The Ss were 75 male and female Sprague-Dawley rats ranging in age from 100 to 200 days at the start of training. Age and sex were balanced over the experimental treatments. The apparatus was a Grason-Stadler operant conditioning unit, consisting of an operant box, with relay and timing units which provided for automatic programming and recording. The box was modified by the insertion of a black and aluminum colored Masonite partition which divided the box approximately in half, and provided the side next to the bar with a black Masonite floor and wall. The left half of the box consisted of the aluminum colored wall of the partition, plus the regular box walls and grid floors. During fear conditioning the CS was the onset of the light, which normally provided "house light" for the box. It was removed from its usual location and hung inside the shock-box section. The UCS was a 3 sec. duration shock delivered through the Grason-Stadler Model 1064GS shock generator set at a dial intensity of 1.0 ma.

The training procedure was the same as that used by Mowrer and Solomon (1954). Its essential features were as follows: On Day 1, S was brought to the experimental room and placed into the food-reward side of the apparatus. There were four .45 mg food pellets in the food magazine. S was permitted to make 20 food reinforced bar presses. The S was transferred to its home cage for 30 min. access to wet mash and then returned to the experimental room and placed into the fear-conditioning side of the box. After 5 min. the CS was presented followed at the appropriate interval by shock. On training Days 2-5 the procedure was the same except that S received only 5 reinforced bar presses instead of 20. On Day 6, S was placed into operant compartment and permitted 5 min. of CRF. Immediately following this period in which each bar press produced a food pellet and the CS.

The independent variables were CS duration during acquisition (p. 5, 5.0, 15, 30, and 60 sec.) which was factorial to CS duration during the suppression test (0.5, 5.0, 15, 30, and 60 sec.).

Results and Discussion

It may be seen in Fig. 1 that substantial response suppression occurred in all groups. Statistical analysis

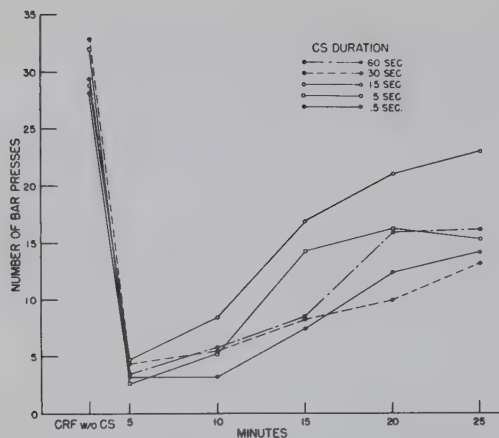


Fig. 1. Mean number of bar presses during the suppression test as a function of CS duration during fear conditioning. CRF w/o CS refers to the 5 min. period of CRF during which a bar press resulted in food reinforcement but no light (CS).

of the difference between the 5 min. of CRF with the first 5 min. of the suppression test revealed reliable response suppression for all acquisition groups. Similar conclusions obtain if the response suppression is evaluated by analysis of extinction durations over all acquisition durations. It should be noted that although the obtained response suppression may be reasonably interpreted as reflecting the aversive properties of the CS, it is also probable that some suppression would have been obtained by merely introducing the novel light stimulus. The appropriate controls are not present in this experiment to separate these two effects.

Although significant response suppression was obtained, factorial analysis of variance of total number of responses during the suppression period revealed no differential effects of CS duration during either acquisition or extinction. Since it was possible that the lack of differential effects might have resulted from the excessive suppression during the first 10 min. of the suppression test, an ad hoc factorial analysis of vari-

ance was applied to the data for the last 15 min. only. Again the results revealed no differential effects attributable to CS duration either during acquisition or extinction.

These results are contrary to those of Carlton & Didamo (1960), Stein et al (1958), Libby (1951), and Lyon (1963) using a CER procedure. They are consistent with results obtained by Brush (1957) who found that CS duration did not effect traumatic avoidance learning by dogs in a shuttle box.

It is our feeling that the lack of differential effects of CS duration in the present experiment may have been due to the fact that the Mowrer and Solomon procedure did not require the operant to be trained to a sufficiently stable level. As a result, variability during the suppression test is quite high and thus masked whatever CS duration effect may have been present. On the other hand, it may be that different functional relations will hold between various independent variables and response suppression, depending on whether the CER or secondary punishment techniques are used. It would appear that an experimental comparison between the CER procedure and the secondary punisher procedure with response rate stabilized would be in order before further experiments are conducted with the secondary punisher procedure.

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Gastric ulceration as a function of food deprivation in isolated and aggregated mice¹

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The incidence and severity of gastric lesions, developed as a result of 24 hr. of food deprivation, was studied in adult mice isolated or aggregated for eight days. Isolated animals showed a reduced amount of food intake, less gastric food retention, a greater incidence of gastric ulcers, and more severe gastric lesions than did the aggregated mice. The isolated animals also showed slightly heavier adrenals and less adrenal ascorbic acid. The data appear consistent with the view that ulcerogenesis in mice is a function of housing conditions which govern activity, food consumption, and the ability to retain food in the stomach.

Gastric ulceration has been experimentally produced in rodents as a result of a variety of agents and/or events. One such event which has been shown to lead to gastric ulcerogenesis in mice is the deprivation of food (Frisone & Essman, 1965). The extent of the pathology was an inverse function of body weight and the extent to which the retention of gastric food particles occurred. It would appear that, since gastric food retention is related, in one respect, to food consumption, those factors which affect food intake should indirectly affect gastric ulcerogenesis produced by the deprivation of food. In mice, population density and age are determinants of daily food intake. Since the latter variable has been explored and shown to affect the incidence of ulcer development (Frisone & Essman, 1965) it was the purpose of the present study to consider population density, directed toward a comparison of the effect of post-weaning isolation or aggregation in the genesis of gastric ulceration resulting from food deprivation. It was a further purpose to consider the contribution of isolation or aggregation as possible stressors to ulcerogenesis. Such a distinction was made by a consideration of resulting changes in the adrenals.

Method

Male CF-1 strain mice were selected from litters matched for age and weight. Following group-housing (10 per cage) from weaning (21 days) until 47 days of age the animals were randomly assigned to either isolated (N=25) or aggregated (N=15) housing conditions. The isolation conditions consisted of individually housing each animal in a plastic cage (17 x 28 x 13 cm) with *ad libitum* food and water. The aggregation conditions consisted of housing five animals to an individual cage under the same conditions.² The animals were not handled pre-weaning or post-weaning except at the onset of the experiment (47 days of age) and at its conclusion (55 days of age).

Daily food consumption was determined by weighing the unconsumed food at 24-hr. intervals. Average daily

food consumption values were obtained for the group-housed mice. On the seventh day all food was removed and body weight was recorded for each animal. Following the 24-hr. food-deprivation period the animals were again weighed and then killed with a lethal dose of pentobarbital sodium. The gastric tissue was excised between the oesophagus at the level of the cardiac sphincter and approximately 20 mm of the duodenum. The tissue was bisected along the greater curvature, the incidence of food particles contained was noted, and following washing it was mounted on index cards. Color positives were made of the gastric tissue and these were rated for the incidence and severity of pathology. The rating scale used was: 0=no gastric pathology; 1=dilated gastric vessels; 2=vascular dilation with hemorrhage; 3=discrete ulceration; and 4=gross ulceration; with vascular dilation and/or hemorrhage. Several specimens of gastric tissue grossly characterized as showing either no pathology or ulceration were fixed, after being photographed, in 10% formalin for subsequent preparation of histological specimens.

For the ascorbic acid assays the adrenals were removed, weighed, and individually homogenized in 5% metaphosphoric acid; a 5 ml filtrate was treated with 0.5 ml of 0-phenylenediamine reagent (0-phenylenediamine, 0.5% in glycerol, diluted to 10% in 1M $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$). The solutions were agitated and incubated for 1 hr. at 32°C in the dark. The samples were read against a treated ascorbic acid standard (2×10^{-4} gm/ml) for fluorescence in a Farrand fluorometer using filters for 405 m μ peak fluorescence.

Results

The histological findings which characterized the gastric tissue which, upon gross inspection, was considered ulcerated, consisted of pathology localized in the body and antral zone of the stomach. There were variations ranging from erosive epithilitis to deeper craters, including infiltration of the muscularis mucosae. There were some instances of necrotic cells and thrombotic inclusions, but no central perforation. Non-ulcerated tissue, in some instances, showed a mild reddening around the fundus and some granulated mucosal tissue.

The results of the comparison between isolated and aggregated animals are shown in Tables 1 and 2. Where-as there was no statistically significant difference between the animals as far as food consumption over the seven-day feeding period, it may be noted that the aggregated mice did consume somewhat more food. As compared with equivalent initial food intake, measured at the onset of the experiment (5.30 gm), both groups showed a

Table 1. Food Consumption, Food Retention, and Gastric Ulceration in Isolated and Aggregated Mice

Condition	N	Mean Daily Food Consumption(gm)	Percent Gastric Food Retention	Percent Gastric Ulceration
Aggregation (A)	13	5.07	46	46
Isolation (I)	25	4.54	23	77

reduction in food consumed by the seventh day. It is of further interest to note that the mean weight loss resulting from the 24-hr. period of food deprivation was equal for both groups (2.8 gm).

It can be seen that significantly more of the aggregated mice had undigested food particles remaining in the stomach than did the isolated animals ($\chi^2 = 7.90$; $p < .01$). The direction of this difference was also consistent for the incidence of gastric ulceration, which was significantly greater for the isolated mice ($\chi^2 = 79.10$; $p < .001$), and the rated severity of the gastric pathology, which was also higher for isolated animals ($t = 24.00$; $p < .05$).

Whereas the differences between the adrenal tissue weights [$\Delta(I-A)$] and adrenal ascorbic acid concentration [$\Delta(A-I)$] did not reach acceptable levels of statistical significance, fairly consistent differences obtained when the weights and concentrations were randomly matched between groups. The mean adrenal weight differences and mean adrenal ascorbic acid differences indicated that the isolated mice had heavier adrenals and less ascorbic acid than did the aggregated animals.

Discussion

The data suggest that the incidence and severity of gastric ulceration occurring in adult mice following 24 hr. of food deprivation are related to the pre-deprivation housing conditions; this relationship appears consistently to suggest that isolation contributed more significantly to ulcerogenesis and gastric pathological severity. Although the observed differences in adrenal weight and adrenal ascorbic acid concentration were not of sufficient magnitude to quantitatively assign either housing condition to a more "stressful" position, the direction of the differences was consistent with predicted adrenal changes resulting from stress; i.e., through randomized matching, those mice with heavier adrenals had less ascorbic acid; such mice were more frequently those which had been isolated.

It seems clear that isolation or aggregation housing for adult mice may serve as a determinant of food

consumption. Whereas the aggregated animals consumed somewhat more food over the period of the experiment, their weight loss with food deprivation was equivalent to that occurring in isolated animals. There was, however, a more clear relationship between food intake and the retention of gastric food particles; this was significantly more evident for aggregated animals; these animals retained significantly more undigested food particles, showed a significantly lower incidence of ulceration, and a significantly less severe degree of pathology.

It may be concluded, on the basis of the data obtained, that food consumption and food retention is greater for aggregated than for isolated mice and that gastric food retention serves a protection function insofar as ulcerogenesis and ulcer severity are concerned. From the data it appears further that a change from group-housing to isolation in adult mice facilitates ulcerogenesis resulting from 24 hr. of food deprivation.

These findings support previous results from this laboratory (Frisone & Essman, 1965) showing that ulcerogenesis is related to food deprivation and gastric food retention. One parallel between the present findings and ulcerogenesis in rats is the relationship between isolation and aggregation and activity differences. Unpublished data from this laboratory have indicated that with post-weaning isolation mice become more active than do aggregated animals. Rats immobilized during the peak of their activity cycle showed more ulcer development than those immobilized during a trough in the cycle (Ader, 1964). In this same study the author suggested that the presence of gastric food particles was related to the activity differences and that gastric food contents appeared to confer some protection against ulcerogenesis. More recently (Ader, 1965), the same author indicated that activity levels and restraint-induced gastric ulcers differed between isolated and group-housed rats as a function of pre-weaning handling conditions, but in the absence of handling these differences were not apparent. Our findings are in agreement with the suggestion that gastric ulcerogenesis and its severity occur more frequently in mice which are more active and retain less gastric food; it appears from the data present that these conditions are facilitated by introducing group-housed adult animals to isolated housing conditions.

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Notes

1. This study was supported in part by USPHS Grant MH-08698-02.
2. Two animals in the aggregated group died on the eighth day of the study. Their gastric and adrenal tissue was not included in the data.

Table 2. Severity of Gastric Lesions and Adrenal Differences as a Function of Isolation and Aggregation

Condition	Mean Severity of Gastric Lesion ($\pm$ SD)	Mean Adrenal Weight $\Delta(I-A)$	Mean Adrenal Ascorbic Acid $\Delta(A-I)$
Aggregation(A)	1.00 $\pm$ 0.6		
Isolation(I)	2.20 $\pm$ 1.2	.00365 mg	4.08 mM/kg

Acquisition, discrimination, and extinction with intracranial stimulation¹

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Two brain areas, the ventromedial nucleus of the hypothalamus and the septum, were compared on each of three variables for intracranial electrical stimulation: acquisition, discrimination, and extinction. The ventromedial nucleus groups had significantly higher response rates during acquisition, significantly more responses during the correct interval in discrimination, and made more responses to extinction than the septal implant groups. Nondiscrimination controls revealed that discrimination training had no effect upon resistance to extinction for either brain area group.

Olds (1956), Olds (1960), and Olds & Olds (1963) have demonstrated that rate of response for intracranial stimulation is a function of the brain area stimulated. It has not been demonstrated, however, that extinction or proficiency at discrimination is a function of brain area stimulated. It was the purpose of this preliminary study to investigate such a possibility.

Method

Sixteen 280-320 gm male albino rats were the Ss. Seven Ss were stereotactically implanted in the septum with stainless steel bipolar electrodes, and seven Ss were similarly implanted in the ventromedial nucleus of the hypothalamus. Two Ss served as nonimplanted normal controls.

There were three phases to the experiment:

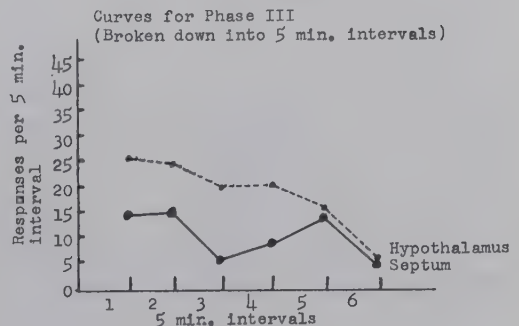
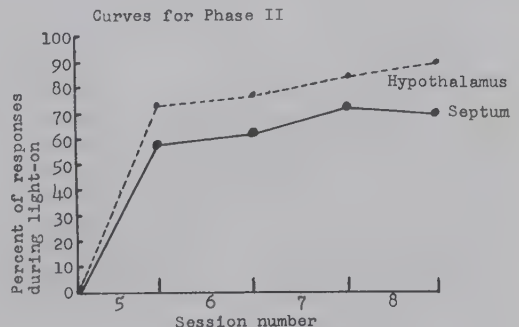
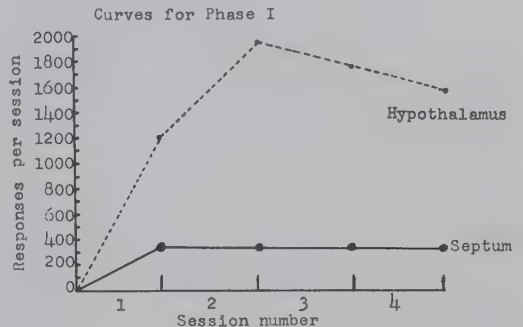
Phase I. Following a three day recovery from surgery all 16 Ss were given training for four daily sessions of 30 min. each in a modified Skinner box. Each bar press delivered a 60 cycle a.c. train to the implanted area for .2 sec. The intensity of the current was adjusted to yield maximal bar pressing rates without seizure for each S.

Phase II. Ten Ss, five hypothalamic and five septal implants, served in the discrimination phase, which also consisted of four daily sessions of 30 min. each. The discrimination phase consisted of turning on a small 6.3 v cue light above the bar when the bar was activated and reinforcement was available to S's electrode for each bar press. When the cue light was off no reinforcement was available to S. The cue light was actually on for a period of 15 min. during the 30 min. session, but was randomly presented in intervals ranging for 15-60 sec. in length. Two Ss in the hypothalamic group and two Ss in the septal group served as controls and did not receive discrimination training so that the effects of discrimination training upon extinction performance could be estimated. Percent of responses made during light-on intervals was taken as the measure for discrimination.

Phase III. All 16 Ss were given a final 30 min. session during which no bar presses were reinforced. The extinction measure was number of bar presses per animal during the session.

Results and Discussion

In Phase I, the acquisition phase, the hypothalamic implant group responded best, with a mean of 1548 responses per session for each animal. The septal



group was significantly lower with 337 responses per session. The nonimplanted control Ss reflect the operant level of the apparatus with 63.4 responses per session. This data, then, supports the findings of other investigators that brain area is a major variable in rate of response for intracranial stimulation.

The data from Phase II also show a significant difference between brain areas. The hypothalamic implant group was again best with a mean of 79.8 percent of total responses made in the intervals during which the cue light was on, as compared to only 67.3 percent for the septal implant group. Data reported here indicate that locus of stimulation is an important factor in the equality of discrimination performance for intracranial stimulation.

Significant differences between brain areas are also shown in the results from Phase III. As in the other two phases, the hypothalamic implant group was significantly higher than the septal group. Ss in the hypothalamic group had a mean extinction score of 102.6 responses, while Ss in the septal group had a mean extinction score of 65.8. Nonimplanted control Ss had a mean of 40 responses during the final session.

It should be pointed out that discrimination training had no effect upon resistance to extinction. The two hypothalamic implants and the two septal implants which received training, but not discrimination training, did not differ from their group mates in extinction. This indicates that extinction scores were not inflated by the discrimination training, as might be expected in some cases.

It seems that the data obtained in Phase III, though

Reply to Weckin and Sackett

by H. S. Pennypacker, James A. Horel, and Shirley A. Myers

In commenting on our previous paper (Myers, Horel, & Pennypacker, 1965) Weckin and Sackett raise two issues which evidently require clarification. The first, concerning the operant nature of the VR, is clearly definitional—they suggest that we have inadvertently identified as an operant VR a response which may in fact have been respondent. The second relates to the origin of vocal behavior and is at best, speculative and interpretational.

We have used the conventional definition of the word operant defined originally by Skinner (1938, p. 21) as "...an identifiable part of behavior of which it may be said not that no stimulus can be found that will elicit it (there may be a respondent, the response of which has the same topography) but that no correlated stimulus can be detected upon occasions when it is observed to occur." From the same reference we find respondent defined as "the kind of behavior correlated with specific eliciting stimuli..."

In our procedure one of a number of existing VRs is selectively reinforced and as typically happens in similar situations, the response increases in frequency

based on only seven Ss in each of the two brain areas, have especially important implications because of the inconsistencies and contradictions found in previous studies investigating extinction with intracranial stimulation. Howarth & Deutsch (1962) reported rapid extinction as a function of time, for instance, yet Herburg (1963) could not predict the effect of manipulating certain variables upon extinction with Deutsch's theory. These apparent inconsistencies could be easily reconciled by systematic demonstrations that the area stimulated is a major factor in the extinction curves for intracranial stimulation. The present investigation, though of only a preliminary nature, suggests that brain area is such a determiner.

Curves for all three phases are presented in the figure.

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Notes

1. Part of this research was reported at the 1965 meeting of the Rocky Mountain Psychological Association, Denver, Colorado.
2. Now at Kansas State University.

until a stable level of responding is achieved. Clearly, the food does not elicit the response, it follows it and "anticipation" of the food is clearly not an identifiable stimulus. Moreover, attention should be called to the fact that the vocal behavior in question was maintained on an FR 3 schedule; the classical conditioning literature is hardly replete with examples of responses maintained over long periods on a 33% reinforcement schedule (Kimble, 1964).

With regard to the origin of vocal behavior, our report simply did not address itself to that question. While it is true that modifying a response by operant methods in the laboratory does not prove that similar behavioral alterations in the natural setting are due to operant conditioning, neither does it preclude such a possibility. Nor does it preclude the unrelated possibility that the behavior initially functioned as a respondent; e.g., the human blink response appears to undergo such modification in the case of the unilateral lid closure which is a significant component of the courtship pattern.

In any case, even if the VR is a food call, we would ask what it serves the animal. Prior to conditioning, the response probably had some functional significance for the animal, but whether it was a food call or mating

Continued on page 256.

An EEG correlate of autonomic discrimination¹

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In a forced choice procedure, Ss can identify the presence or absence of their own spontaneous GSRs. Correctly and incorrectly discriminated GSRs are preceded by opposing patterns of 5 cps EEG activity. It is suggested that discriminable GSRs are produced by the same central events which serve as cues for the discrimination.

Mandler & Kahn (1960) have unsuccessfully attempted to demonstrate discrimination of changes in heart rate within an operant paradigm. The present attack on the problem of autonomic discrimination employed the GSR, a discrete and easily defined response, instead of the more subtle heart rate changes investigated by Mandler & Kahn. In addition, the Ss were given training in controlling their GSR in anticipation that the acquired means of control would provide cues for the discrimination. This training consisted of an operant conditioning procedure coupled with the suggestion that the reinforced response can be produced by emotional thinking, the procedure having been shown to be effective by Crider, Shapiro, & Tursky (in press). EEGs were recorded concurrently because it was felt that central alerting responses would most likely be used as a means of controlling and thus discriminating the GSR.

Method

Electrodermal activity was recorded as the potential difference between two nonpolarizing silver-silver chloride sponge electrodes placed on the thenar eminence of the right palm and the dorsal aspect of the right forearm. A GSR was defined as a palm-negative change in potential of at least .5 mV as recorded via an R-C coupled amplifier having an input time constant of 1 sec. The EEG was measured between standard occipital and temporal leads and recorded on FM tape. It was analyzed at 5 (theta), 10 (alpha), and 20 (beta) cps by playing the tape back through a filter (Becker et al, 1958) and integrating the filter output over 1-sec. intervals (Tursky, 1964). Respiration, measured from a strain gauge respirometer fixed around the waist, and gross skeletal activity, recorded from a vibration transducer fixed to the springs of the S chair, were also recorded to eliminate from consideration GSRs elicited by movement or irregular breathing.

The Ss, 8 males and 2 females between the ages of 19 and 23, were seated in a sound-attenuated, temperature controlled room. They were told that in the first 10 min. of the experiment they would be taught to produce a certain kind of emotional response by thinking,

and that in the next 10 min. their ability to recognize this response would be tested. It was explained that in the first part they would receive a 1000 cps, 1 sec., auditory tone for each emotional response (i.e., GSR) on a 10-sec. DRL schedule, and thereby earn 5 cents. All other GSRs (those following a GSR by less than 10 sec.) would be indicated by a 200 msec. blip. In the second part, the DRL schedule and the blips would continue, but half of the tones would not be contingent upon GSRs. Non-contingent tones were given in a random order at intervals sufficiently greater than 10 sec. from a preceding GSR to eliminate temporal cues. The S was to indicate whether he thought each tone was contingent upon a GSR or not by pressing a "yes" key or a "no" key. Correct guesses earned 5 cents and were indicated by a light. Incorrect guesses lost 5 cents. The 10-min. training and discrimination periods were then repeated. Ss were asked to sit still and not to breathe irregularly.

Results

Although none of the Ss made fewer than 50% correct guesses, only four discriminated significantly above chance ($p < .05$), with 69%, 69%, 78%, and 81% correct guesses.

EEG correlates of GSRs were found by measuring the integrated filter output in each of the 10 1-sec. intervals preceding each GSR. For each S, the amplitude values for each 1-sec. interval of a given frequency were averaged over the correctly identified GSRs and the incorrectly identified GSRs. EEG amplitude per interval was converted to percentage deviations from the mean amplitude of all 10 intervals.

Although there were consistent within Ss correlates of GSR activity at all frequencies, the only results relevant to the discrimination that were consistent across Ss occurred in the 5 cps analysis. Figure 1 shows the averages of each S's EEG correlate for correctly and for incorrectly identified GSRs. It appears that the two correlates tend to vary in opposite directions from second to second.² The stability of the difference between the two curves across Ss was tested by finding for each S the difference in 5 cps activity between correct and incorrect identifications for each 1-sec. interval, ranking these 10 differences, and testing for concordance across Ss by computing Kendall's W. The statistic was significant at the .02 level. Furthermore, a significant across-Ss rank order correlation was obtained between the percent of correct guesses and the variance of the 10 differences in EEG activity between correctly and incorrectly identified

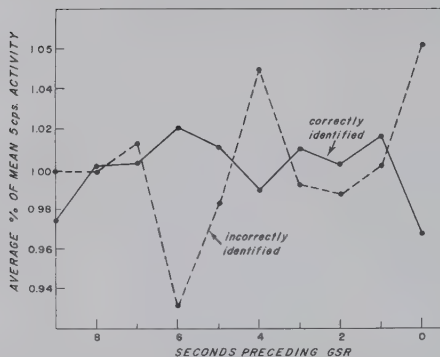


Fig. 1. EEG patterns preceding correctly and incorrectly identified GSRs. Averages of individual patterns for 10 Ss.

GSRs ($\rho = .59$, $p < .05$). Thus differential 5 cps EEG activity preceding a GSR is related to its discriminability, with better discriminators showing a greater EEG differential.

Discussion

The EEG pattern preceding a GSR indicates whether or not it will be discriminated. Since the EEG activity precedes the GSR, the activity cannot be due to afferent feedback from the autonomic change. Thus it is clear that such feedback is not the sole determinant of GSR discriminability.

There are, however, two possible interpretations of the EEG patterns. One is that the pattern preceding discriminated GSRs represents a central event which produces the GSR and in turn serves as a cue for its discrimination. This event would then be discriminable whether or not a GSR were present. This interpretation is in accord with the introspections of the Ss. Good

discriminators reported using cues such as "When a new thought popped into my mind after I had been concentrating on one thing for a few seconds," or "When I thought of emotional experiences."

The other interpretation is that the event indicated by the EEG patterns only modifies the ability to discriminate autonomic feedback from the periphery. In this case, GSR discrimination would require the simultaneous occurrence of central and peripheral events. The preceding central events would not necessarily be discriminable by themselves. A decisive experiment would entail testing for GSR discrimination after deafferentation.

Although a consistent relationship between alpha rhythm alerting responses and GSR discrimination was not found, the importance of the 5 cps activity is consistent with Walter's (1953) view regarding theta rhythm as an indicator of emotion.

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Notes

1. The work forms part of an honors thesis in the Department of Psychology at Harvard College. It was supervised by Drs. David Shapiro and Andrew Crider and Mr. Bernard Tursky at the Massachusetts Mental Health Center. The author is grateful to them for their critical advice and support. Financial assistance was provided by NIMH Grant MH-08853-02 and by ONR Contract Nonr-1866(43).
2. The form of the two curves may result from the tendency of correctly and incorrectly identified GSRs to fall at different phases of periodic fluctuations of 5 cps activity.

Continued from page 254.

call is totally irrelevant. Presumably, any response conditioned by operant methods had some significance to the animal prior to its selective reinforcement. If it is used somehow in obtaining food it is an operant already and we have simply submitted it to further operant conditioning. If it is ordinarily elicited simply in response to food, then we have shown that this response can be operantly controlled.

We are happy to see that our critics support our only conclusion, viz. operant conditioning of the VR of nonhuman primates can be achieved. It is a point on which there has not been unanimous agreement among authorities prior to our experiment (Lilly, 1960; Andrew, 1962).

With our statement on acquisition of VRs back in the context from which it was removed, it is clear that we were not suggesting that all VRs of all animals

are acquired in this way. The point is that there are now a number of experiments demonstrating operant control of VRs in nonhumans. What remains to be demonstrated is whether or not this operant conditioning is different in any fundamental way from the operant conditioning that is postulated as being important in the acquisition of human verbal behavior.

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For comment by Wechkin and Sackett see page 246.

Collateral water drinking in rats maintained on FR food reinforcement schedules¹

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FLORIDA STATE UNIVERSITY

Six food-deprived female rats were tested on a bar press for food contingency under increasing FR requirements. The results corroborated a prandial interpretation of schedule-induced collateral water drinking in that number of meals, total water drunk, and amount of water ingested per reinforcement increased as the FR requirement increased.

Recent studies have shown that food-deprived rats tested on VI, FI, and DRL food reinforcement schedules consistently engage in excessive collateral water drinking (e.g., Falk, 1961, 1964; Segal & Holloway, 1963; Stein, 1964). Increased water intake has also been observed in food-deprived rats tested on FR food reinforcement schedules in which the FR requirements were as little as 33. Increased water intake, however, has been observed less consistently in the response-dependent FR schedules than in time-dependent VI, FI, and DRL schedules (cf. Falk, 1964; Clark, 1962; Stein, 1964). The factors responsible for this phenomenon are not understood; Stein (1964), however, has suggested that the effect is attributable to a schedule-induced thirst factor. Stein has argued that (1) the ingestion of dry food pellets induces thirst, (2) rats typically drink after ingesting some number of reinforcements, thereby signaling the end of a meal, (3) schedule requirements impose restrictive constraints upon the number of reinforcements ingested per meal, thereby increasing the number of meals eaten per session, (4) the net effect of the schedule-induced increase in number of meals is more frequent drinking and, consequently, increased water consumption. The purpose of the present study was to examine the effects of an increasing FR requirement, in a bar press for food contingency, upon meal frequency and water intake. If Stein's thesis is correct, progressive increases in the FR requirement should be accompanied by more frequent meals and increased water consumption.

Method

The Ss were six, 400 day old Sprague-Dawley female albino rats that had previously been used in an alternating acquisition and extinction study in which they bar-pressed for food on a CRF schedule. The previous study was terminated about four months prior to the beginning of the present study. During these four months, the Ss were maintained on ad lib food and water in the home cages.

The apparatus consisted of six Lehigh Valley rat test chambers with a 100 ml graduated water tube installed in place of the right bar. Standard 45 mg Noyes lab rat food pellets which were contingent upon

bar pressing were used as reinforcers. Bar pressing and drinking responses were recorded by relay circuitry, drinkometers, counters, and an Esterline Angus digital operations recorder.

The Ss were first adapted in the home cage to a 21-hr. food deprivation schedule, then tested in daily 3-hr. sessions under FR1, FR5, FR10, FR20, FR40, and FR80 schedules, in that order. Food pellets were available only during the 3-hr. test sessions. Water was available on an ad lib basis in the home cage and in the test chamber. Measurements were taken of bar pressing, food and water intake during the 3-hr. test sessions, and water intake during the 21-hr. home cage periods. Each FR condition was run to stability. The criteria for stability was that each S's total bar-presses and 3-hr. water intake on the last three days of each FR condition were within the range obtained during the preceding six days of that condition. The data presented in this report are based entirely upon each S's performance in the last three days of each FR condition. The FR1 condition served as a baseline from which changes in meal length, number of meals, and ml of water ingested were evaluated.

Results and Discussion

The main results of the experiment are summarized in Fig. 1 where mean reinforcements, mean meals, and mean ml of water ingested by each S during the 3-hr. test sessions and the 21-hr. home cage periods, are shown as function of magnitude of the FR requirement. Four major points may be made from this data. First, water intake in the home cage varied inversely with test sessions water intake. This finding agrees with Falk (1964) and is apparently related to homeostatic mechanisms that regulate total daily water intake.

Second, 3-hr. water intake showed a relatively systematic increase for all Ss, except S3, as the FR requirement increased. All Ss, including S3, drank considerably more water under FR80 than under FR1. Mean ml of water drunk in the FR80 increased, from the FR1 baseline measurement, for Ss 1, 2, 3, 4, 5, and 6 by 127, 69, 58, 192, 80, and 420 per cent respectively. Furthermore, water consumption in the 3-hr. FR80 condition for all Ss approximated and, in some Ss, exceeded total 24-hr. water intake under the FR1 condition.

Third, number of meals increased as the FR requirement increased. For the present analysis, criteria were used which permitted each S to define meal length in terms of its behavior. Specifically, a meal was defined as any number of reinforcements which

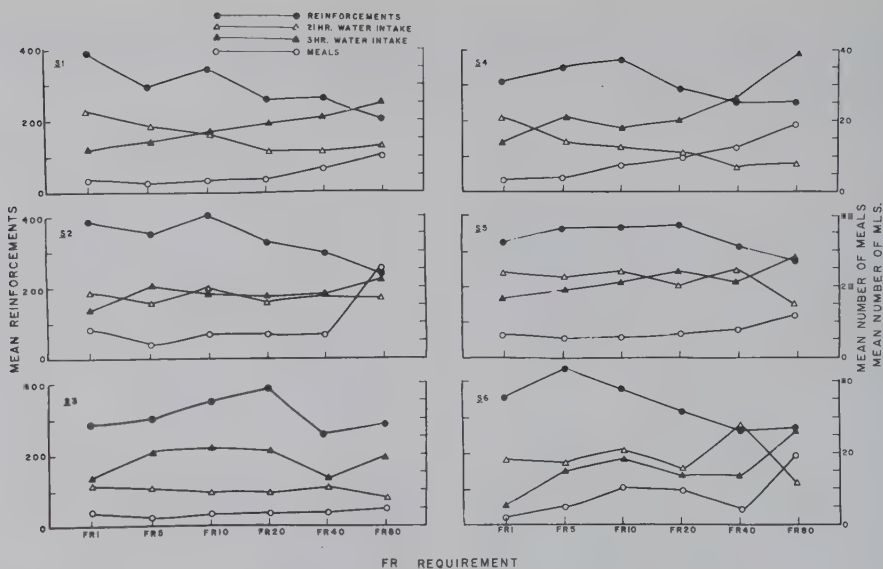


Fig. 1. Mean reinforcements, meals, and ml water ingested in the test sessions, and mean ml water ingested in the home cage periods, as a function of FR requirements.

were terminated by drinking. This definition was specific to each S and independent of the number of reinforcements ingested per meal. This particular definition was used since an analysis of the data indicated that all Ss ate some number of reinforcements, drank, paused, then ate, drank, paused, etc. Since number of meals and number of ml ingested both increased as the FR requirement increased, the present data are conceptually consistent with Stein's (1964) prandial drinking interpretation of increased water intake associated with reinforcement schedules.

Fourth, as the FR requirement increased beyond 20, total number of pellets obtained in the 3-hr. test session decreased. The significance of the increased water intake shown in Fig. 1 is made even more evident in Table 1 where a ratio between mean number of pellets ingested and mean ml of water consumed in the last three sessions of each FR condition is presented. As may be seen from this table, there was a general inverse relation between the ratio and size of the FR requirement. Thus, although the Ss were in

general obtaining fewer reinforcements as the FR increased, they were eating more meals, drinking more water per pellet, and increasing their total water intake as the FR requirement increased.

Although these results are consistent with Stein's (1964) interpretation of schedule-induced increases in water intake, Clark (1962) suggested that the effect depends on adventitious reinforcement. If this were the case, then there should have been a consistent pattern of alternation between drinking and bar-pressing, with drinking always immediately preceding bar-pressing. An examination of the data showed this was not the case: drinking followed, rather than preceded, bar-pressing. Although adventitious reinforcement may influence collateral water drinking in time-dependent schedules, it is apparently an insignificant factor in response-dependent schedules.

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Note

1. Supported in part by Public Service Research Grants MH 08795 and MH 08775 from the National Institute of Mental Health.

Table 1. Ratio of mean pellets eaten per ml of water ingested in the last three sessions of each FR condition

FR Requirement	S 01	S 02	S 03	S 04	S 05	S 06
FR1	35:1	29:1	24:1	24:1	22:1	75:1
FR5	23:1	10:1	15:1	17:1	22:1	32:1
FR10	24:1	24:1	16:1	23:1	19:1	24:1
FR20	16:1	20:1	19:1	16:1	16:1	27:1
FR40	15:1	19:1	20:1	10:1	16:1	23:1
FR80	8:1	11:1	15:1	7:1	11:1	11:1

Motivation and learning in mice after goldthioglucose-induced hypothalamic lesions^{1,2}

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Shock-avoidance training was given to normal mice and to mice with goldthioglucose-induced lesions in the ventromedial region of the hypothalamus. The lesioned mice learned faster than the control mice. Lesions in the ventromedial region of the hypothalamus may alter the emotionality of an animal and thus its motivation during learning.

The role of the hypothalamus in the regulation of food intake has been well documented in the literature. Bilateral electrolytic lesions in the ventromedial region of the hypothalamus in a rat will induce a hyperphagia and subsequent obesity. In contrast to this phenomenon, lesions in the lateral area of the hypothalamus result in aphagia and subsequent starvation.

Much effort has been expended in the elucidation of how these hypothalamic centers regulate food intake. The first experiment of Hetherington & Ranson (1939) 25 years ago and that of Anand & Brobeck (1951) 15 years ago resulted in the concept of dual centers regulating feeding and hunger. Stellar (1954), Teitelbaum (1955) and others have refined and clarified this concept. In addition, they have shown the importance of motivational variables that interact with these hypothalamic centers and thus further influence feeding and hunger.

Recent observation of the behavior of animals after electrolytic ventromedial hypothalamic lesions have suggested that this center may be concerned with functions other than feeding. The experiments reported here investigate the role of the ventromedial hypothalamic region in motivation and learning in the mouse under shock-avoidance conditions.

A single injection of goldthioglucose has been shown to induce bilateral lesions in the ventromedial region of the hypothalamus in mice. These goldthioglucose-induced lesions in mice result in hyperphagia and obesity similar to that seen in rats with electrolytic lesions in this same area (Liebelt & Perry, 1957). The experimental mice used in this study were treated with goldthioglucose in an attempt to make discrete lesions in the ventromedial region of the hypothalamus.

Method

The Ss were 39 adult male mice of three different strains (A/KI, CBA/KI, CBA/JAX). Twenty of the mice represented our control group; the remaining 19, our experimental group. Prior to any training procedure all experimental mice received intraperitoneal injections of goldthioglucose (Solganol B)³ according to weight and strain. These animals showed a rapid increase in food intake reflected by daily weight gains.

The majority of mice started training approximately 22 days after goldthioglucose administration.

Procedure

Experimental and control mice were trained in an electrified Y-maze with a metal grid floor similar to that previously described by Flexner, Flexner, & Stellar (1963). An opaque barrier divided the stem of the Y into a start box and an alley. In order to avoid shock the mouse had to move from the start box, down the alley and into the correct arm of the maze within 5 sec. Shock was given if after 5 sec. the mouse had not entered the correct arm of the maze. For half of the animals the right arm was correct and for the remainder the left arm was correct. Each animal was trained at its own shock threshold level. These thresholds were determined individually for each mouse using a modified method of Evans (1961). Twenty training trials a day were given until a criterion of 80% or more correct responses was reached and maintained for three consecutive days. At the termination of the experiment, the mice were killed, their brains removed from the cranium and prepared for microscopic examination.

Results

All experimental mice and all control mice successfully learned the shock-avoidance problem. Figure 1 compares the training trials of two goldthioglucose-lesioned mice with those of two normal control mice. The goldthioglucose-lesioned mice each required only 40 trials to reach the criterion of learning whereas the two normal mice required 120 and 160 trials respectively to reach the same criterion. Figure 2 shows the results of all experimental and control mice used in

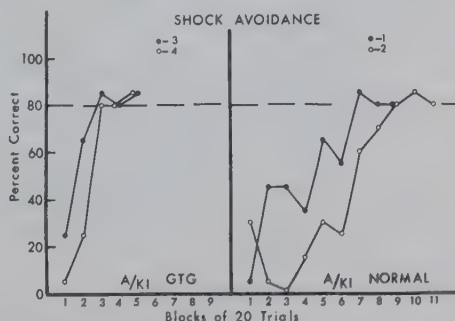


Fig. 1. Learning curves of two goldthioglucose (GTG) lesioned mice compared with learning curves of two normal mice. Each lesioned mouse took 40 trials to reach criterion. Normal mice took 120 and 160 trials respectively.

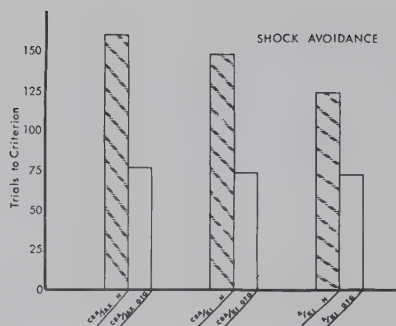


Fig. 2. Comparison of trials to the criterion of learning required by goldthioglucose (GTG) lesioned mice and normal mice according to strain. Regardless of strain, GTG lesioned mice learn more rapidly than normal mice.

this study. Comparison of lesioned to normal mice is presented according to strain. The results shown here clearly indicate that regardless of strain, the goldthioglucose-lesioned mice reach criterion in approximately half the number of trials as their controls.

Discussion

One possible explanation of these present findings requires the assumption of a change in the emotionality of the animal as a result of the ventromedial lesions. Our observations of the mice throughout the experiment support this hypothesis. The first observation was a marked increase in sensitivity to shock (pain) in the goldthioglucose-lesioned mice. Shock thresholds were found to be consistently lower than those of the control mice. Although each mouse was trained at its own shock threshold, latencies of response were shorter in the lesioned mice. In addition, the normal mice showed more "freezing" behavior both during shock and during the 5 sec. interval. "Freezing" was usually accompanied by urination and defecation. On the other hand, the lesioned mice tended to escape from shock quite readily and consequently showed much less "freezing" with a marked decrease in urination and defecation.

The results and observations presented here strongly

suggest that ventromedial hypothalamic lesions alter the emotionality of the animal, affecting its motivation during learning under noxious conditions. Elimination of "freezing" and the resultant shorter latencies in the goldthioglucose-lesioned mouse appeared to help the animal during learning. In contrast, the normal mouse "froze" almost immediately and appeared immobilized in the presence of shock or a signal of on-coming shock. Consequently, this animal may have taken longer to learn because it had to first overcome this emotional response to the noxious situation.

It must be emphasized that although our results appear to be significant no generalization can be made from the mouse to other species such as the rat or cat. We also cannot state at this time whether our results are independent of goldthioglucose and whether similar results would be obtained after electrolytic lesions in this area of the hypothalamus.

Finally, further studies are necessary with food-reward training to determine whether this phenomenon is a general one or is related only to negative reinforcement situations.

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Notes

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3. Courtesy of Schering Corp., Bloomfield, N. J.

Simultaneous double discrimination response following brain bisection¹

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The performance of two choice reactions, one with each hand, in response to two visual discrimination tasks presented simultaneously, one in each half of the visual field, normally takes much longer than the performance of either one alone. In commissurotomed human patients, however, the double task was performed as rapidly as the single task. The results conform with the view that the neocortical commissures serve to unify adjustment to the visual world (Gazzaniga et al, 1965) and their presence tends to prevent the two half brains from making discordant volitional decisions.

When the cerebral hemispheres have been separated by complete surgical section of the neocortical commissures, each of the two disconnected hemispheres continues to function much as before except that their activities lack the high interdependence and unity that normally prevails. It has become clear from a number of studies in man (Gazzaniga et al, 1962, 1963, 1965), as well as in animals (Sperry, 1961, 1964), that the two separated hemispheres continue to cooperate much of the time in performing a single unified function. Each of the two disconnected hemispheres is also able to take over the directive controls of total behavior on different occasions. Left and right hemispheres may alternate in dominating the control of the lower motor system. When one hemisphere is in command, conflicting or interfering activity in the other hemisphere tends, as a rule, to be excluded from the motor system which swings over entirely to mediating the higher functions of whichever hemisphere is dominant at the moment. An exception occurs at times in the control of the hands, especially in man, where dissociated and even antagonistic performances can be carried out simultaneously under certain conditions.

It has been shown experimentally in monkeys that the two separated hemispheres working in parallel are able to perceive, learn, and remember contradictory discrimination tasks under conditions involving a polarized light technique whereby the separate hemispheres are made to see different things in the same place at the same time (Trevarthen, 1962). Rapid alternation of hemispheric dominance within the time span of a response trial in the foregoing could not be excluded. Also there were indications of the presence of unifying factors that tended to favor the use of one hemisphere at a time in a majority of cases.

Beyond the foregoing there is little information available concerning the extent to which the disconnected hemispheres can carry out simultaneously activities that normally would produce mutual interference in the presence of the commissures. The following is the

result of an attempt to investigate this question further in commissurotomed human subjects. A visual discrimination task was flashed to the left hemisphere first and then together with another different discrimination task to the right hemisphere and the reaction times to the single and double presentation were measured and compared with normal and with preoperative readings. The obvious interference produced by pairing the tasks under control conditions stood in marked contrast to the lack of interference that was found to prevail in the absence of the commissures.

Procedure

Four normal and four operated Ss were tested. The operated Ss were all patients of Drs. Philip Vogel and Joseph Bogen of the California College of Medicine and had undergone midline section of the neocortical commissures at the White Memorial Hospital in an effort to control advanced epileptic seizures (Bogen & Vogel, 1962, 1965). Results of other functional studies carried out on these same cases have been reported elsewhere (Gazzaniga et al, 1962, 1963, 1965). All operated Ss, both before and after surgery, were receiving several anticonvulsant drugs in varying amounts, which uniformly slowed down their reaction time both pre- and post-operatively.

Each S was seated in front of the panel pictures in Fig. 1, with gaze fixed on a central point and was instructed to respond as fast as possible to one of a pair of stimuli presented in either or both visual fields. In all Ss the left hemisphere-right hand combination was required to respond to the green of a red-green discrimination pair presented in the right visual field, and the left hand-right hemisphere combination to a light-dark discrimination task in the left field. Each trial was preceded by instructions to the S to look at a central point on the panel. When accurate fixation was attained, as checked by the experimenter behind the screen, the stimuli were tachistoscopically presented (tungsten 24 VDC source energized for 0.15 sec.). Presentation of visual material in this manner insured that stimuli in the right visual field would be projected solely to the

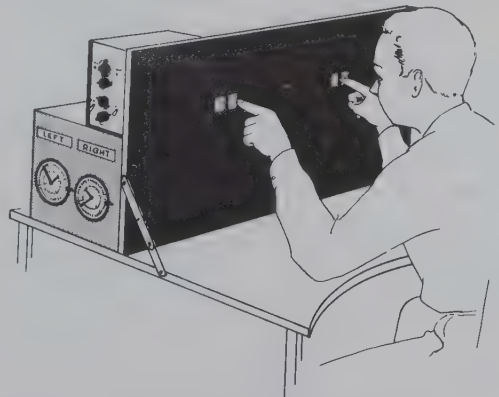


Fig. 1. Testing apparatus: While subject fixated central point, stimuli were flashed onto the translucent response panels.

Table 1. Reaction Times to Visual Stimuli in Milliseconds*

Subject (normal and pre-op.)	R. Hand (Trials 1-10)		R. Hand-L. Hand (Trials 11-20)		R. Hand (Trials 21-30)		$p(M_2-M_1)$	$p(M_2-M_4)$
	M_1	S.D.	M_2	S.D.	M_3	S.D.		
GRN	438	57	695	97	694	96	< .005	< .005
TRB	465	120	770	140	800	120	< .005	< .005
HML	380	55	470	88	464	95	< .05	< .025
SRP	439	228	574	70	678	88	< .005	< .005
Case III (A.A.)	704	176	1272	213	1110	254	< .005	< .005
Case IV (L.B.)	727	158	1667	750	1227	580	< .005	< .005
(operated)								
Case I (W.J.)	1150	138	869	92	798	104	N.S.	N.S.
Case II (N.G.)	766	156	777	153	869	224	N.S.	N.S.
Case III (A.A.)	705	175	724	170	741	199	N.S.	N.S.
Case IV (L.B.)	700	152	594	92	566	114	N.S.	N.S.

* R. Hand responds to red/green discrimination in right half visual field.

L. Hand responds to bright/dark discrimination in left half visual field.

Probability calculated from paired observations by one tailed *t* test. N.S. .05

left hemisphere and stimuli in the left visual field to the right hemisphere. The pair of stimuli for each visual field was presented side by side on two translucent screens 3.5 cm x 4.5 cm by means of a one plant projector unit. The right-left positioning of each pair was interchanged on a pseudorandom schedule. The response time was measured from the beginning of the electronic-flash until the timing circuit was opened by the S's pressing of the correct response panel.

The Ss positioned the index finger of each hand upon the 1/4 in. vertical partition between the two response panels of each pair of screens. Following stimulus presentation the finger thus positioned was moved quickly to left or right on whichever side the chosen stimulus appeared. The entire test sequence took approximately 30 min. The trials were run with the right hand working the red-green discrimination presented in the right visual field. This was followed by 10 trials in which both hands were used in parallel, the left hand responding to the black-white discrimination simultaneously presented in the left visual field with the color stimuli in the right field. Subsequently, the right hand worked alone for ten trials of the red-green discrimination presented in the right visual field.

Results and Discussion

The results are summarized in Table 1. *t* values were calculated from correlated observations because most Ss showed practice effects with the right hand within each series of scores. The normal Ss on the average took 40 percent longer to perform the double discrimination task than when the one task was performed alone. The operated Ss, by contrast, were able to perform the double discrimination-response task as rapidly as they did the single task alone. Preoperative scores were available for Cases III and IV. The reaction times in both of these were slower preoperatively than in the normals, presumably due largely to the anticonvulsant medication. These reaction times in these cases were not significantly increased after surgery.

Absence of the normal increase in reaction time in the operated Ss when they were required to perform two discrimination responses simultaneously, one through

each hemisphere, would seem to indicate a lack of interference through the commissures that was present in the normal subjects. Presumably this reflects a unifying role of the commissures that under normal conditions would act to keep the two hemispheres working in harmony on the same task.

The ability of each hemisphere to carry out separately in parallel a visual discrimination and to respond to it voluntarily with the corresponding hand in no more time than if each were working alone provides further evidence for the view that cerebral commissurotomy creates two separate mental entities each capable of operating in the presence of dissociated function in the other.

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Note

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Role of freezing and fear in avoidance decrements following mammillothalamic tractotomy in cat:

I. Two-way avoidance behavior¹

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In experiment 1, six cats were trained in a two-way conditioned avoidance response (CAR) and then received lesions aimed at the mammillothalamic tracts (MTT). Avoidance decrements following MTT lesions were not related to changes in freezing behavior. In experiment 2, four cats were trained in the CAR and then given intensive fear conditioning (pairing of buzzer and unavoidable foot shock). On subsequent CAR test sessions, avoidance latencies for trials on which the buzzer was added were significantly ($p < .01$) shorter than on trials without the buzzer. Thus, a stimulus (the buzzer) capable of eliciting fear and freezing much stronger than that seen following MTT lesions actually facilitated the CAR (reduced avoidance latencies). This and the results of experiment 1 do not support the hypothesis that avoidance decrements following MTT lesions are attributable to increased fear or freezing.

Although it has been shown that in cats retention of a two-way (shuttle) conditioned avoidance response (CAR) is severely reduced following lesions of the mammillothalamic tracts (Thomas, Fry, Fry, Slotnick, & Kriekhaus, 1963; Kriekhaus, 1964), the exact role of the mammillothalamic tract (MTT) in avoidance behavior is not clear. Thomas et al (1963) suggested that the avoidance decrements might be a result of MTT lesions increasing the likelihood that the innate response of freezing would become prepotent when fear producing stimuli were presented, while Kriekhaus (1964) proposed that the observed changes in freezing are more likely only secondary to an immediate effect on avoidance behavior. The present study will evaluate the role of freezing and other manifestations of fear in avoidance decrements following MTT lesions.

EXPERIMENT 1

In experiment 1 the intensity of responses such as freezing and immobility which are capable of competing with the CAR, was evaluated following MTT lesions. In earlier work (Thomas et al, 1963; Kriekhaus, 1964) the compartments of the avoidance apparatus were so small (floor area was 12 in. x 18 in.) that if the cat did not cross the hurdle there was little else it could do but remain motionless. This made it difficult to assess accurately whether the MTT lesions had really increased immobility and freezing. In the present experiment we repeated the prior work but used a larger avoidance apparatus.

Method

Six mongrel cats, four males and two females, were trained in the two-way CAR procedure described by Thomas et al (1963),

except that in addition to the light CS a tone was added; also each compartment of the shuttle box was 45 in. long, 24 in. wide and 40 in. high. When a cat had reached the learning criterion, electrolytic lesions were stereotactically aimed bilaterally at MTT. Lesioning and histological procedures have been described by Thomas et al (1963). Postoperatively animals were tested for three days (60 trials) under preoperative conditions, except that no shock was administered. They were then retrained to criterion.

Results

In three cats the lesions missed the MTTs completely. On the 60 postoperative test trials cats made 60, 60 and 59 responses and on retraining required 0, 1 and 0 shocks to relearn. They also showed no changes in any manifestations of fear. Two cats with partial unilateral MTT transection made 14 and 40 responses and required 3 and 1 shocks, respectively, to relearn. One cat in which both MTTs were completely transected made no CAR postoperatively and required 12 shocks to relearn. (It had required 70 shocks to learn initially.) The above results are in accordance with our earlier reports concerning the effect of complete, partial and no lesions of the MTT on retention and relearning of a two-way CAR (Thomas et al, 1963; Kriekhaus, 1964).

Although the cat with complete bilateral MTT lesions showed decreased locomotion postoperatively, its behavior was similar to that of a normal, quiet cat, i.e., it made relaxed head movements and meowed, particularly when the CS came on, and yawned occasionally. The two cats with partial MTT lesions not only showed no marked increase in outward signs of fear such as immobility or freezing but usually exhibited behavior antagonistic to freezing. For the cat with the smaller, partial MTT lesions, on those trials on which it did not avoid, including the first such trial, when the CS came on the cat went up to the hurdle, stopped, turned its head and eyes rapidly as if confused, looked back over its shoulder, quickly moved away from the hurdle and returned to the back of the compartment; only then did the cat display any immobility or freezing. The cat with the larger, partial MTT lesion, with CS onset, manifested obvious autonomic signs of fear such as pupillary dilation and pilo-erection but was often observed to walk around the compartment with no particular orientation toward the door, or to walk up to the hurdle, place its front paws on it, look over into the other side, and then turn and walk away.

EXPERIMENT 2

Although these results offer little support for the hypothesis that the avoidance decrements following

MTT lesions are attributable to increased freezing, it is still possible that an aspect of strong fear other than freezing or immobility might mediate these avoidance decrements. Indeed, there is evidence, discussed by Kenyon & Kriekhaus (1965), that increased fear can produce decrements in the two-way CAR. The purpose of the present experiment is to ascertain whether a tremendous increase in fear could produce avoidance decrements comparable to those seen following MTT lesions. When each cat had reached the learning criterion, which previously (e.g., Thomas et al, and experiment 1) was followed by MTT lesioning, it was given intense fear conditioning to a buzzer. The effect of this conditioned fear on the CAR was then evaluated by comparing the number and the latencies of the CARs on trials with and without the buzzer.

Method

Four naive, mongrel cats were trained in a two-way CAR. Procedures and apparatus are described by Thomas et al (1963). When each cat reached criterion, it was given fear conditioning—six CS-US pairings (two per day for three days). The cat was placed in a box similar to the avoidance apparatus for 1 hr. After a randomly determined length of time (mean = 30 min.) a CS, the attenuated sound of a door buzzer, was presented for 34 sec. The last 4 sec. of this CS overlapped the 4 sec. US (4 ma). Following this fear conditioning, the cat was returned to the shuttle box for 32 trials of avoidance testing (16 trials per day for two days). On the first and third blocks of four trials of each daily session the cat was tested as before the CS-US pairings i.e. with the light CS only; on the second and fourth blocks the buzzer was turned on simultaneously with the light CS. Following this testing the animals received 10 more CS-US pairings (two per day for five days). The procedure was the same except the pairings took place in alternate compartments of the avoidance apparatus and the US was 7 ma. Following two more days of avoidance testing, with and without the buzzer, the experiment was terminated.

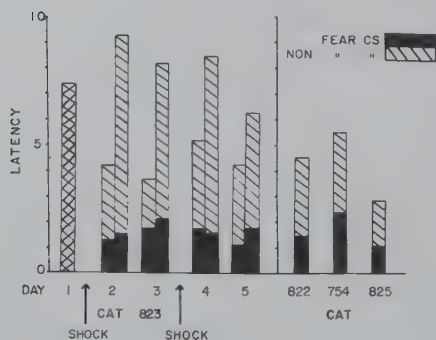


Fig. 1. Avoidance latencies with and without buzzer (fear CS). Striped columns represent average latency to cross the hurdle for blocks of 4 trials without buzzer, while solid columns are with the buzzer. Day 1 is the last day before CS-US pairings. The first column for each subsequent day represents the first block of 4 trials and the second column the second block. Days 2 and 3 are the 2 days following the first CS-US pairings and days 4 and 5 follow the second pairings. For the remaining 3 cats (right side of figure) each column represents total mean latencies for all trials with and without buzzer.

Results

By the third CS-US pairing the cats showed strong and intense freezing reactions to the buzzer. By the second pairing in the second series (in the shuttle box with 7 ma shock), the cats exhibited intense fear reactions even when the buzzer was not on. When the buzzer did come on, fear was intensified to a degree that has rarely been observed in our laboratory in either normal or lesioned cats. The animals defecated and salivated profusely and alternated between increased freezing and an extremely rapid, stereotyped scratching at the walls.

In spite of these intense reactions during the CS-US pairings, in subsequent test sessions no cat failed to avoid on any of the trials on which the buzzer was presented. With buzzer onset, all cats showed a marked fear reaction which consisted of pilo-erection, pupillary dilation and an immediate crouching. A cat usually remained frozen in this manner for approximately 1 sec. and would then suddenly jump across the hurdle in one quick motion. Mean avoidance latencies of cat No. 823, which are typical of the other three cats, are depicted in the left portion of Fig. 1. For the other three cats, total avoidance latencies with and without the buzzer are presented in the right portion of Fig. 1. When latencies were analyzed separately for each cat for each of the four days of testing, mean latencies with buzzer were, in each case, significantly shorter than those without buzzer ($p < .01$; t -tests).

Discussion

Present results offer little support for the hypothesis that MTT lesions produce decrements in avoidance behavior by directly increasing fear or its manifestations such as freezing. When cats with partial MTT lesions in experiment 1 failed to avoid they often displayed behavior incompatible with freezing, and in experiment 2, introduction of a stimulus capable of eliciting extreme fear produced, with no exceptions, improvement, not decrements in the CAR. It is significant that the normal cats in experiment 2 clearly manifested more freezing both during the initial few seconds when the buzzer was turned on in avoidance testing, and during the CS-US pairings than the cat in experiment 1 following bilateral mammillothalamic tractotomy.

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Note

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Role of freezing and fear in avoidance decrements following mammillothalamic tractotomy in cat:

II. Appetitively motivated behavior¹

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Although previous work (Kriekhaus, 1964a; Kriekhaus & Chi, 1966) suggests that it is unlikely that the avoidance decrements following lesions of the mammillothalamic tract (MTT) are attributable to increased freezing behavior, in each case evaluation of freezing was confounded with concomitant changes in avoidance behavior. In the present experiment, freezing following MTT lesions was evaluated independently of avoidance behavior by using either the conditioned emotional response (CER) or an appetitively motivated visual discrimination in which the incorrect response was punished. In neither case was there any indication of increases in freezing or other signs of fear following lesions of the MTT. We thus conclude that the reported increases in freezing behavior following MTT lesions are a result of rather than a cause of a primary decrement in avoidance behavior.

It is now well established that in cats retention of a two-way (shuttle) conditioned avoidance response (CAR) is severely reduced following lesions of the mammillothalamic tract (Thomas, Fry, Fry, Slotnick, & Kriekhaus, 1963; Kriekhaus, 1964a; Kriekhaus & Chi, 1966). It had appeared earlier (Thomas et al, 1963) that this avoidance deficit might be attributable to increased freezing behavior. Although this explanation has received little support in subsequent work (Kriekhaus, 1964a; Kriekhaus & Chi, 1966), these studies can not be considered conclusive since in each case evaluation of changes in freezing was confounded with concomitant changes in avoidance behavior.

The present experiment is intended to evaluate the effect of MTT lesions on fear and freezing behavior in a non-avoidance situation. This was accomplished by using: (1) the conditioned emotional response (CER), a measure which appears to have considerable construct validity in assessing effects of limbic system lesions on fear and freezing (see discussion by Kenyon & Kriekhaus, 1965), and (2) two appetitively motivated visual discrimination responses, on one of which the incorrect response was punished by shock.

Method

The apparatus used for the visual discrimination—a modified Wisconsin general testing apparatus (WGTA)—has been described by Thomas et al (1963) and the apparatus for the CER—a cat Skinner box—has been described by Kriekhaus (1964b). Seven naive, mongrel, female cats served as Ss. Five cats were trained on the CER and the two visual discriminations. One cat (No. 796) was trained on the visual discrimination

without punishment, and on a two-way (shuttle) avoidance response. Results for this cat on the later task have already been reported in a prior study (Kriekhaus, 1964a). The last cat (No. 752) was trained on the CER, both visual discriminations and the two-way CAR. Each cat was taught its respective habits in the order mentioned above.

For the CER each cat was first trained to press the lever for milk with a shaping procedure. When the response rate had stabilized the cat was switched to a VI 30 sec. schedule with a 5 sec. limited hold. After the lever pressing rate had again stabilized, the CER was established. Several minutes after the cat began its daily session of lever pressing for milk a CS (attenuated sound of a buzzer) was turned on for 2 min. A few days later when the cat no longer showed a response to this CS, a 1.0 ma foot shock of 2 sec. duration was given following termination of the CS.

Following CER training the cat was taught the appetitively motivated visual discrimination response described by Thomas et al (1963). Training procedures were the same except that the cats were taught two discriminations. On the discrimination learned first an incorrect response was simply not rewarded with food; this was the procedure used by Thomas et al. On the second discrimination, the incorrect response was also punished with mild foot shock (.5–1.5 ma) delivered through the grid floor. This shock initially elicited freezing and general disruption of ongoing behavior, with the result that many hundreds of trials were necessary to establish both visual discrimination responses.

Following training, electrolytic lesions were stereotactically aimed bilaterally at the MTT. Lesioning and histological procedures have been described by Kriekhaus (1964a). Following a 2 week postoperative recovery period, each cat was tested under preoperative conditions except that no shock was administered.

Results

Of the six cats trained on the CER and both visual discriminations, in one the MTT was destroyed completely bilaterally, in two the MTT was completely destroyed on one side and partially destroyed on the other side, and in the remaining three cats the MTT was completely spared. In all cats there was no change in lever pressing for milk or in either of the visual discrimination tasks. Furthermore, cat No. 796, which sustained a complete MTT lesion on one side and a

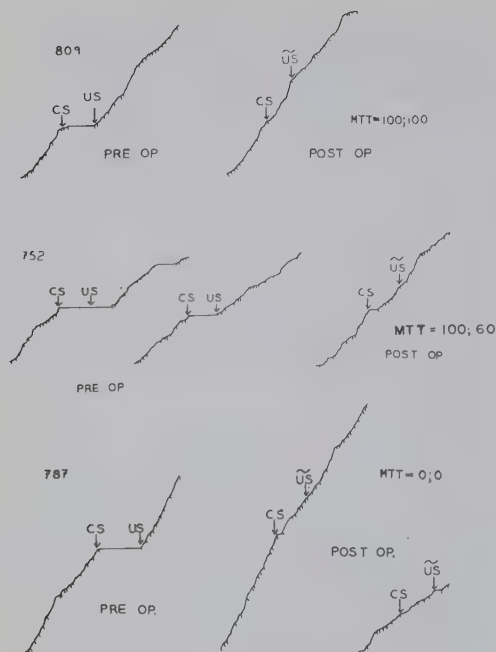


Fig. 1. CER, pre- and postoperative.

partial MTT lesion on the other side and which showed a complete loss of the two-way conditioned avoidance response (Kriekhaus, 1964a) showed perfect retention of this visual discrimination task.

In the case of the CER all six cats lost their CER within the first few days of postoperative testing. In the two cats with the greatest MTT damage and in one cat in which the MTT was undamaged it is clear from Fig. 1 that there was an almost complete loss of the CER from the first postoperative test day. Furthermore, cat No. 752, which had also been trained on the two-way CAR with the same CS used in CER training, failed to cross the hurdle within the CS-US interval on more than half the avoidance trials and required seven shocks to relearn. Clearly one cannot attribute the CAR decrement to increases in fear or freezing elicited by the CS, since the cat showed a complete absence of a CER to the same CS.

Discussion

There now exists considerable data which indicate that the decrements in avoidance behavior following MTT transection are not attributable simply to increases in fear or its manifestations. First, Kriekhaus (1964a) showed in cats with partial MTT destruction and thus less severe avoidance decrements, that any increase

in freezing was noticeable only after the animal had failed to avoid on several trials, and in some cases there was never any noticeable increase in freezing. Second, in the same study the two-way CAR was punished by shocking the cat for crossing the hurdle. Each cat soon learned to stop crossing, and the hurdle jump response was replaced by an intense freezing reaction. There was no tendency for the animals with MTT lesions to stop crossing any sooner than controls. Thus, a change in behavior that presumably would have been facilitated by increased freezing was not enhanced by MTT lesions. Third, Kriekhaus & Chi (1966) have shown that if a stimulus capable of producing intense fear and freezing is introduced along with the regular CS, the animal's avoidance performance is actually enhanced. Fourth, in this same study, when cats were tested in a two-way avoidance apparatus large enough for the cat to move around in if it did not cross the hurdle, CAR decrements after MTT lesions were often accompanied by behavior quite incompatible with freezing. Finally, in the present study, independent of any confounding with changes in avoidance behavior, there was no increase in either the CER or in the effect of fear in disrupting a difficult visual discrimination task following MTT lesions.

We thus conclude that the increase in freezing behavior that has been reported following lesions of the MTT is probably a result, not the cause, of a primary avoidance decrement. This contention is supported by an incidental observation that preoperatively, in the normal cat, marked increases in freezing and other manifestations of fear can be reliably produced by prohibiting the cats from executing the avoidance response. In the two-way CAR this was done by not raising the door separating the two compartments when the CS was presented. In a lever press CAR, the results of which will be reported later, this was accomplished by retracting the lever when the CS came on.

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Note

1. This research was supported by Grant 10885 from the National Science Foundation to the Biophysical Research Laboratory, University of Illinois.

Similarities in effects of barbiturates and mild tranquilizers on activity in mice

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STERLING-WINTHROP RESEARCH INSTITUTE

To determine the extent of similarity in the effects of barbiturates and mild tranquilizers on motor activity, mice were given pentobarbital, phenobarbital, meprobamate, and chlormezanone over a wide range of doses. All drugs increased spontaneous motor activity in photocell units at low doses and decreased activity at higher doses. The drugs resembled each other in producing the same pattern of motor impairment. Ataxia was noted at intermediate doses, and impairment of the righting reflex and ptosis were noted at higher doses. Mention was made of the possible relationship of motor impairment to changes in spontaneous activity and to changes in performance with different schedules of reinforcement.

That meprobamate and barbiturates have many similar effects in man has been stressed by Domino (1962, 1963). Additional similarities in their effects have been found in animals, inasmuch as meprobamate, pentobarbital, and phenobarbital increase the rates of responding in various tests at low doses and decrease the rates at higher doses (Dews, 1955; Ferster, Appel, & Hiss, 1962; Geller & Seifter, 1960, 1962; Kelleher & Cook, 1959; Kelleher, Fry, Deegan, & Cook, 1961; Waller & Morse, 1963; Weissman, 1959). Of particular relevance to the present study, meprobamate and phenobarbital increased spontaneous motor activity in mice at low doses and decreased activity at higher doses (Chen & Bohner, 1960; Gray, Osterberg, & Rauh, 1961; Kinnard & Carr, 1957). But much extrapolation is necessary to draw any conclusions from the animal work because the range of doses has been narrow, because only one drug was used, or because only slight changes in behavior were observed. Indeed, Berger (1963) has stressed the differences between meprobamate and barbiturates rather than the similarities.

To determine the extent of correspondence between the effects of two barbiturates, pentobarbital and phenobarbital, and two mild tranquilizers, meprobamate and chlormezanone, over a wide range of doses in mice, spontaneous motor activity was measured in photocell units (for chlormezanone see Siegler, 1962; Surrey & Conrad, 1962).

Method

Male albino mice (ICR) weighed 18-24 gm at the start of testing in the 12 photocell cages. Each cage, disc-shaped, 3-3/4 in. high and 16 in. in diameter, had metal sides, wire mesh floors, and plastic ceilings. In ambulating from one half of the cage to the other, the mice broke the beam from an Autotron photocell unit, the only source of illumination in the experi-

mental chamber. The photocell interruptions were recorded for two consecutive 15-min. periods on impulse counters outside the experimental chamber.

Thirty min. before the start of testing the mice were orally medicated at a volume of 1 cc/0.1 kg with either drugs suspended in 1% gum tragacanth or a suspension of 1% gum tragacanth (control vehicle) and then were detained in cages which were similar to their living quarters. At the start of testing four mice that had received the same agent were put in each photocell cage. There were a total of four replications (16 mice, $N=4$) for each dose and 14 for the control vehicle (56 mice, $N=14$). Doses in mg/kg follow: pentobarbital sodium at 30, 45, 90, 135, 150; phenobarbital sodium at 25, 50, 75, 150, 200, 300, 500; meprobamate at 62.5, 125, 250, 500, 600; chlormezanone at 50, 100, 200, 300, 400, 500. The mice were observed for signs of motor impairment 30, 45, and 60 min. after medication.

Results and Discussion

Figure 1 shows the mean number of photocell interruptions on the arithmetic scale and the doses on the logarithmic scale. With increases in doses of all drugs, activity increased to values above the control level and then decreased to doses below the control level. According to the Mann-Whitney U test the spontaneous motor activity of the control group was significantly different ($p < .01$) from the drug groups at the following doses (mg/kg): pentobarbital sodium, 30, 45, 90, 135, 150; phenobarbital sodium, 50, 75, 150, 200, 500; meprobamate, 250, 600; chlormezanone, 50, 100, 200, 500. It should be noted that the curves for the two barbiturates were like those of the two tranquilizers. Mention

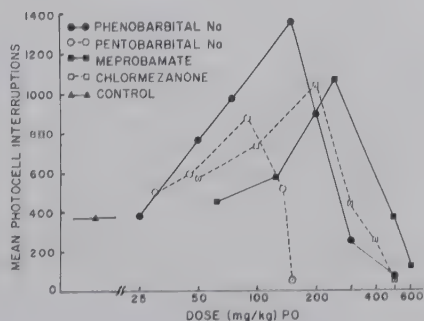


Fig. 1. Spontaneous motor activity as a function of dose.

has already been made in the introduction section that pentobarbital, phenobarbital, and meprobamate seem to increase activity at relatively low doses and decrease activity at higher doses in various test situations. The central nervous system stimulants like amphetamine also exhibit this biphasic action. Thus, low doses of amphetamine increase spontaneous activity, while large doses decrease activity.

Possibly related to changes in activity were motor effects such as ataxia, impairment of the righting reflex, and ptosis (see Table 1). Ataxia was noted at intermediate doses at which the mice were relatively active in the photocell units, whereas impairment of the righting reflex and ptosis were noted at higher doses at which the mice were much less active. With the psychomotor stimulants such as amphetamine the marked increases in spontaneous activity are not accompanied by ataxia or other motor deficits. Impairment of motor reflexes may also affect the results of tests in which the task or schedule of reinforcement has been varied. One should be cautious in attributing performance changes to variations in tasks per se before one excludes the possibility that the performance changes reflect differences in the capacity of drugged animals to make various responses.

Table 1. Doses Producing Impairment of Motor Reflexes

Drugs	Ataxia	Impaired Righting	Ptosis
Pentobarbital Na	90	135, 150	150
Phenobarbital Na	200	300, 500	500
Meprobamate	250, 500	600	600
Chlormezanone	200, 300, 400	400, 500	500

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Visual cliff preferences following lesions of the visual neocortex in cats and rats¹

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Normal cats, cats with lesions of the visual neocortex, normal rats, enucleated rats, and rats with lesions of the visual neocortex were tested on Gibson's visual cliff for visual depth perception. All animals preferred the shallow side except rats that were enucleated and rats that sustained visual neocortical ablations.

Much research in the area of visual depth perception has been stimulated by the classic experiment of Walk, Gibson, & Tighe (1957). By means of the visual cliff technique, these authors concluded that rats could discriminate distance and that this ability to perceive visual depth was probably innate. Since Smith (1937) reported that optic nystagmus, presumably another innate visual response, was present in cats after removal of the visual cortex, Meyer (1963) assessed the cortical dependency of depth perception in cats with extensive neocortical ablations. As measured by the visual cliff, the neodecorticated animals avoided the deep side as often as normal cats. The present experiment replicated the Meyer study (1963) and extended it to determine if the result could be obtained in another species.

Method

Cat. The Ss were eight adult cats. Four served as normal controls and four were subjected to lesions of the visual neocortex.

The visual cliff apparatus was constructed within a 24 x 48 x 30 in. plywood box topped with a sheet of glass. The interior walls and floors contained 3 x 3 in. black and white checks, and a trapezoidal starting platform, 6 in. high, was centered on the glass (deep side). The floors were transilluminated from below with controlled light intensities to match luminous flux. A trial was initiated by centering S on the platform, and a response was recorded when both front paws contacted the glass surface. S received one trial each day for eight days. The right-left position of the deep side was alternated according to a random series, and data were analyzed by a Mann-Whitney U test.

Rat. Eighty adult rats, 90-120 days old, were divided randomly into three groups. Twenty Ss were normal controls; 20 were enucleated bilaterally; 40 received bilateral lesions of the visual neocortex.

The rat cliff measured 18 x 38 x 18 in. It also was covered with glass, which was divided by a 3 in. wide and 3 in. high starting platform. The walls and floor were covered with 1/2 in. sq. black and white checked wallpaper, and illumination was from below through the cliff floor. The initiation of each trial and the response

criterion were the same as for the cat Ss. If the rat Ss did not respond within 5 min., a "no response" trial was recorded, but only five such responses occurred.

The Ss were run one trial per day for three days, and were exposed to the following three lighting conditions: (1) shallow-side-brighter (0.9 ft.-lamb. vs. 0.5 ft.-lamb.); (2) deep-side-brighter (0.9 ft.-lamb. vs. 0.5 ft.-lamb.); (3) both-sides-equal (0.9 ft.-lamb. vs. 0.9 ft.-lamb.). The presentation of the lighting conditions was distributed such that each of the three conditions occurred 1/3 of the time on each test day, and following completion of the experiment, all conditions had appeared equally often. The brightness measures were approximated at the rat's eye level near the starting platform by means of a Weston light meter. The apparatus was rotated to eliminate left-right position responding, and the data were analyzed by chi square tests.

Surgery and Histology. Cat surgery was performed aseptically by subpal aspiration of Visual areas I and II, while Ss were under sodium pentobarbital anesthesia. The visual neocortex of rat Ss also was removed by suction, but no sterile precautions were taken.

Following behavior tests, all Ss with cortical lesions were perfused with 0.9% saline followed by 10% formalin, and the brains were embedded in celloidin. They were sectioned at 30 μ , stained with cresyl violet and analyzed for retrograde degeneration in the dorsal lateral geniculate nuclei (LGN).

Sixteen rats sustained lesions that resulted in complete degeneration of the LGN. Since no behavioral differences were noted between Ss with either complete or incomplete lesions, all were included in the data analysis.

Histological analysis of cat V-22 revealed complete retrograde degeneration in the LGNs, extensive degeneration in the pulvinar nuclei, and unusually enlarged lateral ventricles. Cats V-51 and V-27 showed some sparing that was restricted primarily to the posterior, dorso- and ventro-lateral LGN. The amount of sparing in the left and right LGN was approximately 20 and 21%, respectively, for V-51, and 65 and 25%, respectively, for V-27. Unfortunately, cat V-46 died prior to perfusion.

Results

The cat data are summarized in Table 1. Note that all operated and normal Ss responded to the shallow side on Day 1. Three normal Ss continued to respond to the shallow side, but N-60 developed a position

Table 1. Visual Cliff Responses

	Normal Cats				Visual Cats			
	N-3	N-26	N-39	N-60	V-22	V-27	V-46	V-51
Initial Choice	S	S	S	S	S	S	S	S
Shallow Side(%)	100	100	100	75	87.5	62.5	100	100

tendency after Day 3. Although one operated cat responded to both sides equally often after Day 1, no differences were observed between the two groups.

The rat data are summarized in Table 2. On Day 1, the Normal Group chose the shallow side more frequently than the deep ($p = .025$), but on subsequent days, they responded to both sides equally often. The Enucleate Group performed at chance levels throughout the experiment. None of the lighting conditions biased the choices of either group. For the first two test days, the Visual Group could not be distinguished from the Enucleate Group. Curiously, on Day 3, rats with visual lesions selected the deep side more frequently than the shallow ($p < .01$), but the result could not be accounted for either in terms of position responding or brightness preferences on that test day.

Discussion

Both normal cats and those with lesions of the visual neocortex avoided the deep side of the visual cliff, a finding similar to that obtained by Meyer (1963) in cats with more extensive neocortical ablations.

Table 2. Percent Responses to Shallow Side

	Normal Rats	Enucleated Rats	Visual Rats
Day 1	75	55	47.5
Days 2 & 3	55	45	36.3

However, rats with visual lesions behaved like control animals that had been surgically blinded; they showed no preference for either side during the first two test days.

The fact that both species were not maintained under equivalent living conditions, might possibly account for the rat-cat discrepancy. Prior to surgery, rats were housed in group cages, but following surgery for a three week recovery interval, they were placed in more restricted, 7 x 9-1/2 x 7 in. individual cages. In contrast, the cats pre- and postoperatively, lived in large outdoor 4 x 8 x 7 ft. group wire mesh cages, that contained boxes, which provided an opportunity for jumping and climbing. Since it has been reported (McGuigan, Loizos, & Carr, 1963) that cliff preferences can be modified by previous proprioceptive experience, it is conceivable that environmental experience following surgery could have influenced cliff choices. On the other hand, it is entirely possible that the difference in cliff preference between rats and cats with visual lesions is one of species.

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Note

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Effect of punishment on extinction of an avoidance response: Facilitation or inhibition?¹

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The present study varied intensity and duration of punishment and level of training in an attempt to produce facilitation of responding by punishment during extinction of an avoidance response. Animals were trained to avoid shock in a shuttlebox to a criterion of 2, 4, or 8 consecutive avoidance responses. The Ss were then put on a punishment-extinction schedule. Five intensities and two durations of punishment were used. No evidence for facilitation by punishment was found. Inhibition of responding was directly related to both intensity and duration of punishment but unrelated to level of training.

Under what conditions does punishment facilitate avoidance responding during extinction and under what conditions does it inhibit responding? On the theoretical side this is a question of interest that stems from the "vicious circle" hypothesis introduced to experimental psychology (cf. Mowrer, 1960, p. 486) some years ago. On the empirical side it is a question of current interest because experimental psychologists have not yet spelled out the conditions that produce facilitation on the one hand and inhibition on the other.

The present research investigated the effects of punishment on extinction in a setting designed to maximize the possibilities of obtaining facilitation during extinction. According to most theoretical analyses (Mowrer, 1960; Solomon, Kamin, & Wynne, 1953; and Church, 1963) punishment is more likely to facilitate behavior when the experimental design makes it difficult for S to discriminate the conditions of punishment from those of avoidance training; and when punishment is administered shortly after the CS onset, thereby maintaining fear previously conditioned to the CS. Discrimination of acquisition and punishment conditions is believed to be most difficult in an apparatus such as the shuttlebox where S moves from one identical compartment to another and back again in response to a conditioned stimulus. In such an apparatus fear cannot be conditioned to specific geographical cues, such as the start box during conditioning and the goal box during punishment-extinction. Similarly, response latencies in the shuttlebox are typically short, maximizing the likelihood that punishment will condition additional fear to the CS. Another variable that may affect S's ability to discriminate between acquisition and punishment conditions is the degree of overlearning. Early in training the experimental contingencies should be less well differentiated by S thereby leading to greater generalization of punishment-induced fear.

Subjects

The Ss were 264 195-245 gm female Sprague Dawley rats purchased from a commercial supplier.

Apparatus

An automatic shuttlebox was used (Brush & Knapp, 1959). The sides of the box were aluminum, the top Plexiglas, and the floor, 3/32 in. stainless steel grids spaced 1/2 in. apart. The box was divided into two identical compartments by an aluminum partition equipped with a 3 x 3 in., top-hinged door. Photoelectric cells, located 2-3/4 in. from each side of the partition and 1 in. above the floor were operated by S's passage through the doorway, and served to track S's position and terminate the trial after CS or US had started.

The CS was a 6 w light in combination with a 10 cps click produced by two externally pulsed relays. Bulbs and relays were mounted over the Plexiglas at the end of each compartment. The US was 185 V delivered to the grids through 150 K. ohms in series with the rat. Shock was scrambled through a 12 bank, 10 position stepping switch.

Procedure

Five punishment intensities (45, 72, 115, 185, and 300 V), two punishment durations (.15 and 2.0 sec.), and three criteria for avoidance training (2, 4, or 8 consecutive avoidances) were employed. Eight animals were used in each condition. A non-punished group at each training level was included.

Avoidance training. The S was placed in the shuttlebox and after 30 sec. the CS came on in the compartment occupied by S. If S did not change compartments in 5 sec., the US came on and both CS and US continued until S moved to the other compartment. If S changed compartments in the 5 sec. CS interval, the US did not come on and S avoided foot shock. Thirty sec. was the intertrial interval used throughout the experiment.

Punishment-extinction. Thirty sec. after S reached the learning criterion, the CS came on and remained on for 5 sec. or until the S moved into the adjacent compartment. If the S did not change compartments in the 5 sec. CS interval, the CS went off, terminating the trial. If S crossed to the adjacent compartment within the 5 sec. CS interval, S received the punishing shock appropriate to the group to which it was assigned.

Results

Acquisition. The mean number of trials to reach criterion (excluding criterion trials) was 12.7, 15.1, and 22.0 for the 2, 4, and 8 trial groups respectively. An analysis of variance on these data showed training criterion to be significant ($F = 11.26$, $df = 2/263$, $p < .001$).

Extinction. Figure 1 shows the mean number of latencies under 5 sec. during extinction. No evidence for facilitation by punishment was found at any training level or any punishment intensity. A three-way analysis of

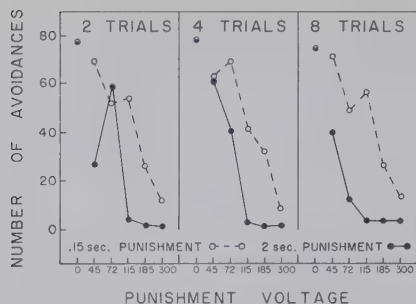


Fig. 1. Mean number of avoidance responses during extinction as a function of level of training and intensity and duration of punishment.

variance on these data showed voltage and duration variables to be significant (voltage: $F=36.08$, $df=4/210$, $p<.001$; duration: $F=68.55$, $df=1/210$, $p<.001$). The training-trials variable did not approach significance ($F=.64$, $df=2/210$). The duration $\times$ voltage interaction was the only significant interaction ($F=41.2$, $df=4/210$, $p<.01$). A similar analysis on response latencies during extinction showed a similar pattern of significance levels.

To further analyze the results, the 2, 4, and 8 avoidance criterion groups were combined because of the absence of any tendency for the groups to differ during extinction. Figure 2 shows the combined response latencies in 10 trial blocks during extinction for the .15 and 2.0 sec. duration punishment groups. Response

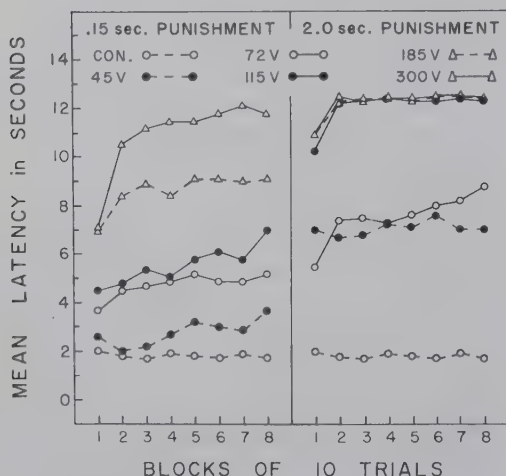


Fig. 2. Mean response latencies in blocks of 10 trials during extinction for .15 and 2.0 sec. duration punishment groups at each punishment intensity. Each curve represents the combined latencies of the 2, 4, and 8 avoidance criterion groups.

latencies decreased systematically as punishment intensity increased, and the longer the punishment the greater the depression in running speed. There was no evidence of more rapid responding for punished groups than for control groups.

Discussion

This finding is in direct opposition to that predicted in the introduction and leads us to examine the causes of our failure to find facilitation of responding at any of the conditions employed in this study. First, it is possible that facilitation is found only in highly over-trained animals such as those in the Solomon, Kamin, & Wynne study (1958). Their animals had had hundreds of successful avoidance conditioning trials before punishment-extinction. Introduction of punishment produced relatively rapid extinction in some dogs but, more typically, an increase in response speeds and prolonged running into the punishing stimulus. Second, in our apparatus the response consisted of running through a small swinging door into another chamber. Movement through the door terminated the CS which consisted of a buzzer and flashing light, and punishment must have acted to condition fear to the response or the cues associated with the response of moving through the door instead of augmenting the fear originally conditioned to the onset of the CS. Thus it is possible that the homogeneous characteristics of the shuttlebox designed to make the conditions of acquisition and punishment-extinction difficult to discriminate were offset by the distinctive characteristics of the CS.

In the present experiment it appears that punishment produced an avoidance gradient conditioned to the response of moving to the adjacent compartment proportionate to the intensity and duration of punishment. When the punishment-induced avoidance gradient exceeded the fear originally conditioned to the CS during avoidance conditioning, cessation of responding resulted. In the larger sense, these results do not deny the existence of facilitation of responding by punishment during extinction of an avoidance response. They do suggest, however, that facilitation of responding by punishment is the exception rather than the rule, and that the conditions which generate punishment-induced facilitation are as yet not delineated.

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Notes

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2. Now at the University of Rhode Island.

Transitory effects of experiential deprivation upon reversal learning in dogs¹

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Impairment of place learning of beagles reared under restriction during early life was greatly reduced in successive reversal series. Most isolation-reared dogs were eventually able to reverse responses after one or two errors. Problem-solving ability was not permanently impaired by restricted rearing.

The effects of experiential deprivation during early life upon problem-solving of adults have been reviewed by Hunt (1961). Experiments may be divided into two groups, those in which a specific sensory modality is restricted and effects are sought primarily within the same modality as with Riesen (1947), and those in which more general effects of sensorimotor restriction upon associative learning are of primary interest as with Thompson & Heron (1954). Learning deficits are commonly found in mammals reared under conditions of low stimulation, but the interpretation of the mechanism by which the effects are produced is not entirely clear. Conceivably the impairment could be based upon faulty organization of information-processing systems as appears to be the case in kittens with monocular visual deprivation (Wiesel & Hubel, 1963). Alternatively, the mechanism for processing information may be intact, but still malfunction because the organism is emotionally disturbed in the testing situation.

If the psychological deficiencies are the result of faulty perceptual organization occurring during critical periods of development, they should be resistant to any but highly specific ameliorative therapy. If they are simply a manifestation of emotional disturbance, they might disappear as learning trials were repeated in a benign environment.

Method

An experimental investigation of the persistence of learning deficits was conducted with 16 isolation-reared and six pet-reared beagles. The isolates were held in special cages from 3 to 15 weeks of age as described previously (Fuller, 1963). Pet-reared Ss lived and were fed in the same type of cage, but were allowed the run of the laboratory twice each day while an attendant was present. During this time they were treated as pets. Both groups were then observed during 20 arena tests of approximately 8 min. duration each. The experimenter gave extra handling to some of the isolates during this period, but since this treatment had no detectable effect upon the performance described in this paper, the isolates are considered as a single group. All dogs

were 23 to 26 weeks old at the beginning of training.

The test device was a modified Wisconsin General Test Apparatus which remained stationary during use. Dogs were pulled back from it between trials by a rope running over a pulley and attached to a harness. Between trials a curtain concealed the apparatus from the view of the S. Two food pans with sliding opaque covers were recessed in a low platform 6 in. above the floor. Ss were trained to push the slides and obtain a teaspoonful of commercial dog food. When a dog was performing well it was allowed five free-choices with both sides baited and open. Position response training was then begun with both sides baited and the preferred side locked. Correction was not allowed. Sixteen trials were given per day. The criterion for learning was nine consecutive correct trials within a day. The day following attainment of criterion a new series was started with the correct side reversed. Twelve series were completed.

Results and Discussion

The number of errors prior to attainment of criterion are shown for all Ss in Fig. 1. Pet-reared dogs made fewer errors on the average in all series. However, the difference was by far the greatest on series 2, the first reversal. Ranks of the two groups were compared by the two-tailed Mann-Whitney U-test. Pet-reared Ss made fewer total errors in the combined series ($p < .05$). The difference is largely attributable to series 2, 3, and 4, ($p < .05$). Differences on the first series and on the last five series combined were non-significant ($p > .10$).

The persistence of a mean difference favoring the pet-reared Ss was attributable to high error scores of a few isolates. If making more than five errors above the group mean is considered as a "poor series," we find that pet-reared Ss had an average of 0.83 poor series, all occurring in the first half of the experiment. Isolates had an average of 1.88 poor series. Four had zero, 7 had 1, 2 had 2, and 1 each had 4, 7, and 8 poor series. There is no obvious explanation for the consistently poor performance of three of the isolates, for after the first few series they responded readily and showed no overt fear. The two poorest performers came from one litter, but the genetic significance of this fact is conjectural since two other isolates from the same litter performed on a par with pet-reared Ss. It is noteworthy that an isolate made the fewest errors, and that a majority of both groups were meeting criterion with two errors or less by the end of the

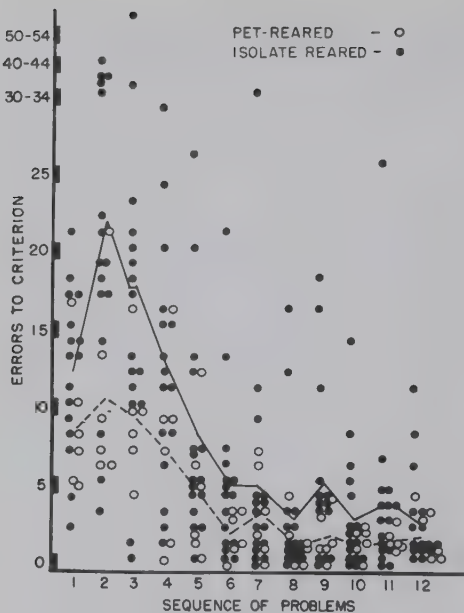


Fig. 1. The number of errors made prior to attainment of criterion for each S on a series of 12 place-learning problems. The correct position was reversed at each new series. The solid line is the mean for isolate-reared Ss; the dashed line is the mean for pet-reared Ss.

experiment. Thus, restricted rearing for 12 weeks following weaning does not prevent the formation of a reversal set.

The initial reversals appeared to disturb the isolates suggesting that they were particularly vulnerable to

sudden changes in reinforcement contingencies. In most isolates, however, the effect was transitory. The data are better explained by a hypothesis of inappropriate emotional arousal which disappears during repeated testing than by a hypothesis of faulty perceptual organization. Type of problem, manner of postisolation handling, length of isolation and species might be varied in other experiments to determine whether impermanence is a general feature of postisolation impairment of performance. It may be that functions which depend upon perception in a single sensory modality will prove more permanently vulnerable to experiential deprivation than are general capacities such as the acquisition of a reversal set. At the moment it is premature to regard a decrement in performance following experiential restriction as equivalent to a general depression of learning ability. Hunt's (1961) conclusion that intelligence is not fixed by genes may have as a counterpart that it is not fixed by early experience either.

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Note

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Resistance to extinction of an escape response as a function of the number of reinforcements¹

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Support for the assumption that response strength is related to number of reinforcements in a negatively accelerated monotonic fashion has been obtained from instrumental appetitive and classical aversive conditioning situations. The relationship is investigated in an instrumental aversive (escape) situation and the results support the assumption.

The evidence generally cited as support for Hull's (1943) assumption that habit strength (S^H) is related to the number of reinforcements in a negatively accelerated monotonic fashion comes from the studies of Perin (1938) and Williams (1942). Their data were obtained in an appetitively motivated instrumental conditioning situation. Evidence from aversively motivated classical conditioning situations has also tended to support Hull's assumption (Kimble & Dufort, 1956; Prokasy, 1958; Spence & Rutledge, 1964).² In the present study resistance to extinction as a function of the number of reinforcements was investigated in an instrumental aversive situation.

Method

Subjects. The Ss were 60 naive, male hooded rats of the Long-Evans strain, ranging in age from 100 to 140 days at the beginning of the experiment. During the experimental period they were housed in individual cages with Purina lab chow and water available ad lib.

Apparatus. The main apparatus consisted of a start box, straight runway, and a goal box. The start box and alley were painted light gray and the goal box was painted flat black. A 60-w light bulb was located 6 in. above the center of the start box. The start box was divided into upper and lower compartments by a trap-door floor located 4-1/2 in. from the top of the box. The S could be placed into the upper compartment through a door at one end, and dropped onto the grid floor by releasing the trap door.

The straight runway was 4 ft. long. Its floor was composed of stainless steel rods 1/2 in. from center to center. This grid extended into the start box. Vertical photocells and associated electronic equipment were used to measure start time (the time between the moment S landed upon the grid until he left the start box), alley time (time required to traverse the runway), and total time (starting time plus alley time).

The lamp above the start box served as a CS. A motor-driven circuit breaker in series with the lamp provided two .25 sec. "on" and "off" periods per second. The interval between the onset of the CS and drop of S onto the grid was approximately 6 sec. Cessation of the CS was controlled by a photocell circuit.

Procedure. Prior to training, each S was handled a few minutes daily for three days and randomly assigned to one of four groups. The groups differed according to the number of escape training trials (4, 8, 16, or 32) received before extinction. Either 1, 2, 4, or 8 trials were administered per day for 4 days with an intertrial interval of 4 min. Start time, alley time, and total time were recorded on each trial. The procedure for a given trial was as follows: 3 sec. after S was placed into the top compartment of the start box, the goal box guillotine door was raised which started an electronic timer. Three sec. later the CS was turned on and 6 sec. after that S was dropped onto the grid. During the last 3 sec. of the 6 sec. CS duration, S received auditory and vibratory cues from the trap-door release mechanism. The CS continued until the rat entered the goal box. The S remained in the goal box 15-20 sec. while time measures were recorded. The 60-volt shock was obtained from the output of a variable-voltage autotransformer and was administered through a series resistor of 10,000 ohms.

After training, Ss received extinction trials at the rate of 10 trials per day, with the same intertrial interval, for the next 6 days. The extinction criterion was failure to reach the goal box within 60 sec. on any one trial.

Results

Acquisition. Performance of the four groups during acquisition is shown in Fig. 1. The points representing alley speed were obtained from medians of blocks of four trials. Although initial increases in speed were

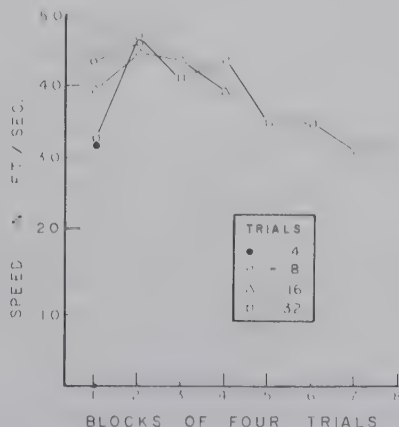


Fig. 1. Median speed in ft. per sec. during acquisition over blocks of four trials.

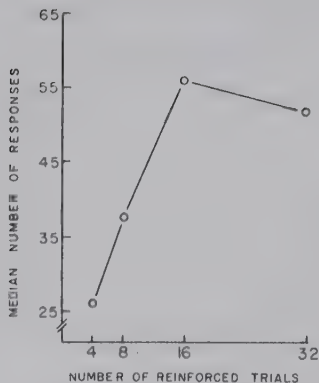


Fig. 2. Median number of responses to extinction for each group over six days of extinction, 10 trials per day.

shown by the 8, 16, and 32 trial groups, the 16 and 32 trial groups showed decrements in speed over the last few blocks of trials. An analysis of variance revealed no statistically significant differences across trials.

Extinction. The median number of responses to extinction for each group is shown in Fig. 2. The figure clearly shows that greater numbers of responses were required for extinction after greater numbers of training trials, except for the 32 trial group. An overall chi-square analysis of these median scores revealed that the groups differed at the .01 level ($X^2=14.15$, $df=3$). A t-test between the 16 and 32 trial groups revealed no significant difference between them.

The mean starting speeds during extinction for the four groups over trials are presented in Fig. 3. Although the

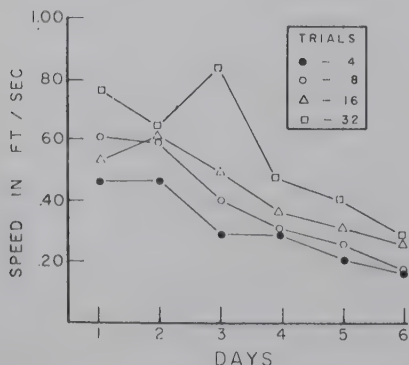


Fig. 3. Mean starting speed during extinction over six days of extinction, 10 trials per day.

groups receiving greater numbers of trials were faster at almost every point, analysis of variance failed to reveal significant differences for this measure. The mean alley speed and mean total speed scores did not show any rank order differences between the groups during extinction. The alley speed scores of the 4 trial group were clearly below other groups and showed rapid extinction, but the other groups showed frequent inversions across trials.

Discussion

The results provide some support for the assumption regarding the growth of response potential with increasing numbers of reinforcements. The number of responses to extinction measure provided the most support, followed by the start speed data. The other speed measures were equivocal. The results also indicate that asymptotic resistance to extinction (when trained with the given voltage levels and intertrial interval) is reached between 16 and 32 trials.

Thus, a similar relationship between resistance to extinction and number of reinforcements has been shown to occur in both classical and instrumental as well as appetitive and aversively motivated situations. Whether a similar over-training phenomenon is found in an instrumental aversive situation, as has been shown in the instrumental appetitive situations, remains to be seen.

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Notes

1. This study was supported by NIH grant M-4952, Judson S. Brown, principal investigator. Submitted in partial fulfillment of MA degree at the University of Florida. The author gratefully acknowledges the guidance of Dr. Brown in this study.
2. A number of experimenters have reported a non-monotonic relationship after large numbers of reinforcements (Hill & Spear, 1963; Ison & Cook, 1964; North & Stimmel, 1960), however, the negatively accelerated relationship was still found and aversively motivated studies have not shown such an "overtraining" effect.

Effects of shock schedules on the acquisition and extinction of escape behavior^{1,2}

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Three groups of albino rats (N=12 Ss per group) received 72 escape training trials in a hurdle-jumping apparatus, with shock presentation on 33%, 66%, or 100% of the trials, followed by 72 extinction trials. Performance during acquisition was directly related to percentage of shock presentation ($p < .001$); performance during extinction, in terms of relative scores, demonstrated the PRE ($p < .01$).

Runway studies by Jones (1953) and Melvin (1963) demonstrated that the resistance to extinction of escape behavior was inversely related to percentage of shock presentation during shock-escape training. Considering the acquisition of escape behavior, however, Jones reported that an intermittent schedule of shock presentation produced faster total running speeds and reliably faster starting speeds than did a continuous schedule of shock presentation; while Melvin reported a direct but non-significant relationship between alley speed and percentage of shock presentation. The present experiment attempted to clarify the relationship between shock schedules and escape behavior by using a different training situation and a greater number of training trials than were used by Jones and Melvin.

Method

Apparatus. The apparatus consisted in a start box and a safe box, each 11-1/4 in. long by 3-1/2 in. wide by 5-1/2 in. high (interior dimensions), separated by a guillotine door on a hurdle 2-1/4 in. high. The start box was painted white and had a grid floor consisting of 30 stainless steel rods, 1/8 in. thick, set 3/8 in. apart. The rods were wired in an alternate-bar system for the delivery of 50 volts (dc) shock to S from a constant voltage source. S provided the only resistance in the shock circuit. The safe box was painted black and had a solid floor which could be depressed.

Additional compartments, each 10-1/2 in. long by 3-1/2 in. wide by 13 in. high (interior dimensions), served as lids for the start box and the safe box. Each lid contained a 7-1/2-watt lamp which provided an intertrial illumination of 7 ft.-c in each lower box. The lid of the start box also contained a 40-watt lamp for the CS, which was an increase in start box illumination from 7 ft.-c to 110 ft.-c. The illumination was diffused into the lower boxes through frosted Plexiglas 3/16 in. thick.

Subjects, Design and Procedures. Ss were 36 experimentally-naïve, female, Holtzman albino rats 99-106 days old. They were randomly assigned to three groups (N=12 Ss) to receive escape training with shock presentation on 33%, 66% or 100% of the trials.

Following a day on which S explored each side of the apparatus for 6 min., each S received in succession, 2 days of 36 escape training trials per day and then, 2 days of 36 extinction trials per day. The minimal intertrial interval was 45 sec. During escape training, a shock trial consisted in placing S into the start box and, after 10 sec., opening the guillotine door, thereby simultaneously producing the onset of the CS, the shock, and a timer (calibrated in .01 sec.). If S jumped the hurdle, the safe box floor depressed, terminating the CS and the timer. After 10 sec., S was removed from the apparatus. If S failed to jump the hurdle within 40 sec., S was removed from the start box with the CS, the shock, and the timer remaining on and a 40-sec. latency was recorded. Non-shock training trials and extinction trials were conducted exactly like shock training trials, except that no shock was presented. The sequence of shock (+) and non-shock (-) trials, during training was + - + - - - - + - + - - + - - - + for the 33% group, and + - - - - + - - - - + - - - - + - - - + for the 66% group, repeated over blocks of 18 trials. The measure of performance was reciprocal of latency of hurdle-jumping.

Results

Figure 1 shows that on each trial block of training, escape performance was directly related to percentage of shock presentation. A trend analysis of variance over all the training data yielded significant effects for

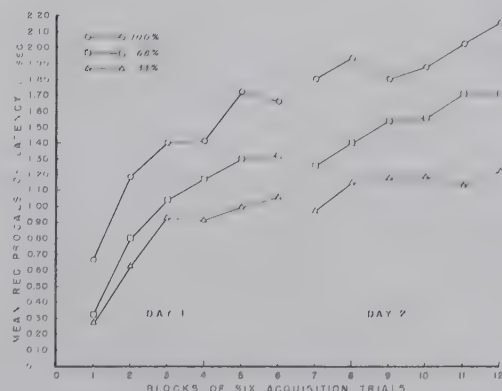


Fig. 1. Mean reciprocals of latency of hurdle-jumping during training for groups that received shock on 33%, 66%, or 100% of the trials.

Percentage of Shock ($F=25.71$, $df=2/33$, $p<.001$) Trial Blocks ($F=70.21$, $df=11/363$, $p<.001$) and Percentage of Shock by Trial Blocks ($F=1.82$, $df=22/363$, $p<.025$). To investigate the significant interaction, an analysis of variance and t-tests were applied to the data of Trial Blocks 1 and 12 separately. The analysis of variance showed that Percentage of Shock was significant on Trial Block 1 ($F=10.00$, $df=2/33$, $p<.001$) and on Trial Block 12 ($F=25.85$, $df=2/33$, $p<.001$). For Trial Block 1, the results of the t-tests, with 33 df, showed that the 100% group was superior to the 66% group ($t=7.23$, $p<.001$) and to the 33% group ($t=8.30$, $p<.001$) but that the 66% and the 33% groups did not differ significantly ($t=1.06$, $p=.30$). For Trial Block 12, the results of the t-tests showed significant differences beyond the .001 level, with 33 df, for all percentage group comparisons: 100% vs. 66%, $t=6.88$, 100% vs. 33%, $t=14.53$, and 66% vs. 33%, $t=7.66$.

Figure 2 shows that extinction performance, in general, was directly related to performance at the end of acquisition. Since the analysis of the terminal acquisition data indicated that the performances of the percentage groups represented different populations at the start of extinction, extinction performance was evaluated in terms of relative extinction scores (Anderson, 1963). Relative extinction data, called percent difference scores, were obtained for each S on each trial block of extinction by dividing mean performance on the last trial block of acquisition into the difference in mean performance between the last trial block of acquisition and each trial block of extinction. The percent difference scores showed that on each day of extinction, resistance to extinction was inversely related to percentage of shock during training (i.e. 33% > 66% > 100%).

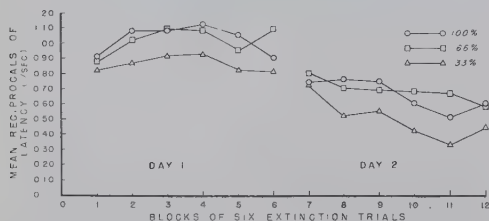


Fig. 2. Mean reciprocals of latency of hurdle-jumping during extinction for groups that received 33%, 66%, or 100% shock during escape training.

Analyses of variance of the overall percent difference data on each day of extinction showed: for Day 1 (Trial Blocks 1-6), Percentage of Shock ($F=5.82$, $df=2/33$, $p<.01$) Trial Blocks ($F=2.53$, $df=5/165$, $p<.025$) for Day 2 (Trial Blocks 7-12), Trial Blocks ($F=8.93$, $df=5/165$, $p<.005$) Percentage of Shock by Trial Blocks ($F=2.08$, $df=10/165$, $p<.025$). The significant interaction was explained with results of analyses of variance which showed that the factor, Percentage of Shock, was significant on Trial Block 7, ($F=4.00$, $df=2/33$, $p<.05$) but not on Trial Block 12 ($F<1$).

Discussion

Since Jones' results may be attributable to the starting speed measure, the discrepancy between his acquisition data and those of this study will be discussed in terms of the conditions of escape training in the start boxes of these two studies. Briefly, Jones dropped S into the start box with the shock or non-shock condition already present on the grids. On shock trials, this procedure may have elicited behavior incompatible with escape (e.g. Sheffield & Temmer (1950) reported the recurrence of "freezing" behavior under similar starting conditions). Due to the frequency of shock occurrence, the depressant effects of these incompatible responses may have been greater for the continuous-shock group than for the intermittent-shock group. In the present study, the 10 sec. interim S waited in the start box before shock onset may have decreased the probability of incompatible responses and may have provided for the occurrence of a postural response (e.g. a "ready" posture), which facilitated escape-from-shock behavior. Thus, due to the greater frequency of shock, the continuous-shock group should perform better than the intermittent group.

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Notes

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2. This research was supported by Grant No. 20-97-152 from the Research Institute of Southern Methodist University.

Effect of amygdaloid lesions on avoidance learning in the rat¹

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Rats with bilateral lesions in the basolateral amygdaloid nuclei were taught to press a lever to avoid electric shock. The difficulty of the avoidance task was manipulated by using an auditory or visual cue to signal the preshock period during which an avoidance response could be made. Amygdaloid lesions had no effect, either disruptive or facilitative on either the easy or difficult task. The effect of septal lesions on the acquisition of easy and difficult avoidance tasks obtained by other investigators is compared with the results obtained in the present experiment.

Permanent alterations in affective behavior associated with damage to the amygdaloid nuclei have been found in cat (Horvath, 1963), rat (Robinson, 1963), and monkey (Weiskrantz, 1956). Loss of fear motivated responses is one of the most commonly reported changes following injury to these nuclei. As would be predicted by the hypothesis that avoidance learning is dependent on fear reduction (Miller, 1951) amygdectomy has been found to impair the acquisition of an active avoidance response. However, while there is ample evidence that damage of the amygdaloid complex in primates or carnivores interferes with avoidance learning (Schreiner & Kling, 1953; Horvath, 1963; Gloor, 1960) results obtained with rats are less conclusive. Kling (1958) could find no effect of amygdaloid lesions on rate of acquisition in a shuttle box. More recently, Robinson (1963) reported similar negative findings using a Miller shock-escape box. On the other hand, Kellicutt & Schwartzbaum (1963) report marked impairment in the formation of a conditioned emotional response following amygdaloid lesions.

Possible reasons for these different findings could include species differences (Nakamura, 1962), transient or delayed changes in the lesioned area and differential destruction of various subnuclei (Ursin & Kaada, 1960). Another possibility which may account for the results mentioned above is that given changes in fear may have differential effects upon the acquisition of an avoidance response depending upon task difficulty. For example, it has been shown that septal lesions which have been hypothesized to reduce fear (Kenyon, 1965) enhance acquisition of a two way (difficult) conditioned avoidance response but retard acquisition of a one way (easy) conditioned avoidance response.

In order to test for the possibility that amygdaloid lesions have similar differential effects upon acquisition of a "difficult" as opposed to an "easy" avoidance response, a visual or an auditory cue was used as

conditioned stimuli in the present experiment. The results of a previous study with normal rats showed that it is much more difficult for a rat to learn a bar press avoidance response when a visual stimulus is used as a conditioned stimulus than when an auditory one is used (D'Amato, Keller, & DiCara, 1964).

Subjects

Ss were 16 experimentally naive albino rats of the Sprague-Dawley strain weighing approximately 375 gm. Eight of the rats were amygdalectomized and the remaining eight were sham operated. Within each of these two groups, half of the rats were trained with an auditory and the other half with a visual stimulus.

Surgery and Histology

Electrolytic destruction of the amygdaloid nuclei was performed under Nembutal and Chloral Hydrate anesthesia. Two small holes, one over each hemisphere, were made in the exposed skull using a dental drill. The electrolytic lesions were made stereotactically using a 2 ma direct current for 20 sec. The sham operated controls underwent the identical procedure except for the passage of current. Ss were allowed a three week post-operative recovery period. At the completion of testing each rat was perfused with physiological saline and 10% formalin. The brain was then removed, fixed in formalin for one week and then sections cut at 40 microns and stained with cresyl violet.

Procedure and Apparatus

A commercial Skinner box was used. The auditory stimulus, a 1000 cps tone at 84 db was fed through a small speaker while the visual stimulus consisted of an increase in illumination provided by a 60 watt bulb in the experimental chamber. Ss were kept in semi-darkness between trials. Each trial consisted of a 5 sec. presentation of the CS, either sound or light, followed by the UCS (a continuous electric shock of 1 ma intensity delivered through a grid scrambling device) and CS until S pressed the lever. If S pressed the lever during the 5 sec. CS presentation period the shock was not given. If S did not press the lever during the 5 sec. CS presentation period, the CS stayed on until the animal made a response. On the first day of training S was shaped to make an escape response. The following day S received 500 consecutive trials. The trials were spaced by a film tape programmer with a mean intertrial interval of 30 sec. and upper and lower limits of 90 and 15 sec. All data (number of escape and avoidances) was recorded automatically.

Table 1. Percentage of avoidance responses made by individual amygdalectomized and control Ss given an auditory or a visual CS.

	Amygdalectomized	Control
Auditory	9.9	12.8
	17.6	22.5
	21.4	27.0
	39.3	34.7
Visual	0.0	0.0
	0.6	0.1
	3.2	1.5
	7.1	2.7

Results

The mean percentage of avoidance responses for each S in the lesion and control groups under visual and auditory CS conditions are presented in Table 1.

It is clear that in both lesion and control groups the 1000 cps tone was a more efficient CS than was the increase in illumination. An analysis of variance showed that these differences were significant at the .001 level ($F=18.6$); however, within a particular CS condition there was no difference between lesion and control Ss in their ability to learn the avoidance response ($F=.26$). Interaction between CS sense modality and lesion versus control groups was also significant ($F=.37$).

Microscopic examination of the lesions revealed complete destruction to the basolateral nuclei in all lesioned Ss. Some Ss sustained damage to the globus pallidus and fringe of the internal capsule.

Discussion

The CS manipulation used to vary the difficulty of the avoidance task was successful. Both the lesion and control groups given the auditory CS made significantly more avoidance responses than the corresponding groups given the visual CS. On the other hand, amygdaloid lesions had no effect, either disruptive or facilitative on either the "difficult" or "easy" avoidance tasks. This finding is in contrast to what has been reported by Kenyon & Kriekhaus (1965) in septal

animals performing easy or difficult shuttle box avoidance. Since it has been suggested that both septal (Kenyon & Kriekhaus, 1965) and amygdaloid lesions (Gloor, 1960) reduce fear one might have expected to find that amygdaloid lesions would have different effects on the acquisition of an avoidance response depending upon task difficulty.

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Note

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The effect of cutaneous vibration on weight loss

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The local administration of 1 hr. of cutaneous vibration through the locomotion surface contact extremities of 10 white rats produced a marked loss (over 2%) in gross body weight. The weight losses which were significantly greater ($p < .01$) than two control groups could not be accounted for by an increase in activity. After examining several alternate views, the author postulates a facilitating effect on the catabolism of fatty tissue to explain the effect.

One of the most widespread yet least explored influences on behavior is vibration. There has been some work done rather incidentally using vibration as a stimulus in psychological scaling (Stevens, 1959) and in studies on cutaneous channels of communication (Bice, 1953; Geldard, 1957, 1961; Howell, 1956). In addition vibration has been used to test Hebb's (1949) theory of affective arousal as well as Helson's (1959) adaptation level hypothesis (Hunt & Quay, 1961; Soskin, 1963). Since Hunt & Quay's (1961) study has been subject to serious criticism by Hoffman & Bell (1962) these studies leave us with only one piece of unequivocal information concerning vibration per se. That is, animals will work to escape it.

Two earlier studies have demonstrated that whole body vibration has profoundly debilitating (sometimes lethal) physiological and behavioral effects (Schaefer, Link, Farrar, Wiens, & Dinsmore, 1959; Schaefer, Ulmer, & Link, 1959). However, since virtually all vibration encountered in nature is of the locally administered, cutaneous variety, whole body vibration seems to be primarily a laboratory artifact with no environmental analog.

It is to investigate some behavioral and physiological effects of locally administered, cutaneous vibration, that a current series of studies is being conducted. This first experiment is an examination of the effects of vibration, locally administered through the locomotion surface contact extremities, on gross body weight.

Method

Subjects. The Ss were 30 male DUB/SDD white rats obtained from a local supplier. The Ss were housed three to a cage on ad lib food and water in a room adjacent to the experimental room. At the start of the study Ss were 99-103 days old and averaged 331.8 gm in weight.

Apparatus. The apparatus was a 9 in. by 7 in. Plexiglas cage, mounted totally independent of its floor. The cage floor was a sheet of 3/8 in. thick Plexiglas painted black on the underside. Bolted firmly to the center of the floor was a 24 V, 4200 rpm (no load) electric motor with

an eccentric on the drive shaft. This unit produced a steady vibration of approximately one-sixteenth in. amplitude with an estimated frequency in the neighborhood of 2000 cps. Oscillographic monitoring showed that the vibration was evenly distributed about the entire floor.

Bisecting the long dimension of the cage was a photoelectric beam with a red filter which insured its invisibility to the rat. This device provided information as to the animals' activity during the experimental session.

The entire unit including the cage and activity monitoring equipment was mounted in a sound attenuating cubicle to eliminate the sound of the recording equipment and other environmental noise.

Procedure. The Ss were randomly divided into three groups of 10 animals. Group V (331.0 gm mean initial wt) received 1 hr. of vibration, group N (333.3 gm mean initial wt) was placed in the apparatus on a supplementary floor for 1 hr. so that they received the sound accompanying vibration (90 db) without receiving the vibration itself. The third group S (331.2 gm mean initial wt) was placed in the same cage for 1 hr. receiving neither sound nor vibration.

Each S was weighed before and after the experimental sessions which were randomized to equalize the influence of the different times of day.

Results

The weight loss and activity data are presented in Table 1. The data were analyzed with Duncan's Range Test. The weight loss differences between group V and group N as well as those between group V and group S were significant ($p < .01$). The differences between group N and group S were not significant, nor were there any significant differences between groups on the activity measure.

Discussion

The data indicate that vibration, locally administered through the locomotion surface contact extremities, produces a significant ($p < .01$) loss in gross body weight. The activity data indicate that this loss is not

Table 1. Group mean number of activity responses and mean % wt. loss over the three treatment conditions.

Treatment	Silence	Noise	Vibration
Mean number of activity responses	195.6	186.8	175.8
Mean % weight loss	0.972	0.813	2.077

the product of an increase in activity, at least of the type of activity measured here. This leads us to look for another mechanism to explain the effect.

There remain several broad possibilities to account for the data, all centering around the animals' metabolic processes. The first concerns the excretion of waste products. This process has been shown to be related to the emotionality of the animal. Indeed, defecation has often been used as a behavioral measure of emotionality, although the use of urination as an index of emotionality seems to have been ignored. The little information that does exist concerning defecation in rats is based only on bollus counts and there is no data on the weights involved. The nature of this particular apparatus made it impossible to measure these variables, and since the literature offers little further enlightenment on this subject, the magnitude of this effect remains uncertain. However, Bolles² states that it is highly unlikely that losses as great as these (over 2% of total body weight in 1 hr.) could be accounted for in this manner. A study is now underway to examine just this question.

If, as it seems very unlikely, defecation and urination cannot account for all of the weight loss there is another metabolic process that may provide us with the solution. That is, vibration may cause an increase in the animals' rate of breaking down fatty tissue. The next question is just how does it cause this increase in catabolism? Does it work through stimulating some internal mechanism(s) or does it simply provide an external mechanical augmentation of an internal process? Another position could result from a combination of the two preceding ones. Although these questions remain unanswered they present some fascinating avenues for further research which could yield valuable information regarding both mechanism of weight loss

and the relationship between internal processes and the external environment.

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Notes

1. The author wishes to express his sincere thanks to Dr. Ronald L. Webster and Dr. Robert C. Bolles for their invaluable assistance throughout this study.
2. Robert C. Bolles, personal communication. 1965.

Spontaneous alternation and scopolamine¹

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Rats were tested for spontaneous alternation following injections of saline, scopolamine, and atropine, using doses of 0.4 and 1.2 mg/kg. It was found that scopolamine, at the higher dose, resulted in a reduction of alternation to a rate very near chance. A possible relation between the effects of scopolamine injection and removal of the hippocampus was discussed.

The anticholinergic drugs of the belladonna family, in addition to being potent parasympathetic blocking agents, also produce marked changes in the electrical activity of the brain. Scopolamine, for example, has been found to abolish theta activity in the hippocampus (Stumpf, Petsche, & Gogolak, 1962), and to counteract or block the theta-inducing effects of eserine (Stumpf, 1964). This drug apparently effects the entire theta system, as it simultaneously reduces the synchronous firing of the septal B units which are "pacemakers" for hippocampal theta waves. It might be expected that this blocking of theta activity would be accompanied by some loss of function of the hippocampus, and that these drugs should produce some behavioral changes similar to those found after the removal of the hippocampus. The present authors, in reviewing the literature, found that many parallels do indeed exist. Whitehouse (1964) found that atropine injections interfered with the learning and performance of a successive discrimination problem, while Kimble (1963) found hippocampectomized rats to be very deficient in learning this problem. Hearst (1959) found pronounced perseverative tendencies, as well as deficits in extinction after scopolamine injection, and these effects have also been reported to occur following hippocampal removal (Kimble & Kimble, 1965; Peretz, 1965). Carlton (1961) found that scopolamine and atropine, especially the former, interfered with performance of a delayed bar press, while Clark & Isaacson (1965) reported a large deficit in learning a similar delay in hippocampally ablated rats. Carlton (1961) also found that scopolamine greatly interfered with the performance of an alternating bar press task, while Gross, Chorover, & Cohen (1965) found a similar defect after hippocampectomy.

In the present experiment this apparent parallel between the effects of these drugs and removal of the hippocampus was further investigated by testing the effects of two dose levels of scopolamine and atropine on spontaneous alternation in the rat. The term "spontaneous alternation" refers to the tendency of the rat to enter opposite alleys on consecutive unrewarded trials in the T maze (see Dember & Fowler,

1958). Normal rats alternate alley entrances at a high rate of about 80%, but this tendency is markedly reduced by even small hippocampal lesions, and apparently completely abolished by larger lesions (Roberts, Dember, & Brodwick, 1962; Douglas & Isaacson, 1964). There is probably no behavior which is changed to a greater extent by hippocampal removal than spontaneous alternation, and if these drugs interfere with hippocampal function this effect should be readily observable as a reduced rate of alternation. Both atropine and scopolamine were used because they have similar peripheral effects, but differ in their central effects, with scopolamine being more potent.

Method

Subjects Ss were 18 male hooded rats from a population bred at the University of Michigan. All were roughly 6 mos. old, and the average weight was 350 gm. All were individually housed, with food and water ad lib.

Equipment A T maze of the following dimensions was used: Length of main and side alleys, 2 ft.; alley height, 6 in.; width, 5 in. The main alley contained a 6 in. starting box which was separated from the rest of the maze by a sliding door. Sliding doors were also located at the entrances to the side alleys. The maze floor was wooden, and the maze covered with wire mesh. Illumination was provided by a 7-1/2 watt hooded light bulb placed directly over the choice point.

Procedure Testing procedure consisted of placing S in the start box and, after a 10 sec. wait, raising the door to the main alley. When S's whole body was present in one of the side alleys, the door to that alley was lowered and the response scored. After a 10 sec. wait, S was removed from that alley and replaced in the start box for the next, identical, trial. Each S was given three such trials on a given daily session, with an alternation score of 0, 1, or 2. These scores were used for statistical testing of drug effects, but for convenience the results have been presented in percent alternation form.

All Ss were first tested on one session with no injections, and were then tested on three daily sessions after injection with either atropine or scopolamine (0.4 mg/kg) or an equivalent volume of a saline solution. Each S received each drug condition, and the order of administration was varied. There are six possible sequences in which three drugs can be administered, and three animals were randomly assigned to each sequence. All injections were intraperitoneally, and testing began 25 min. after injection.

One week after completion of this first test, the experiment was repeated with a higher dose of 1.2 mg/kg.

Results

Spontaneous alternation before injection occurred at a rate of 83.3%, which is a typical rate for normal rats. At the low dosage used in the first drug test, neither atropine nor scopolamine results in significant changes in alternation scores: Atropine, 78%; scopolamine, 81%; saline, 78%. On the second test, however, when the dose was increased from 0.4 to 1.2 mg/kg, the results were different. The saline-injected rats continued to perform normally (77.8%), atropine injections had a minor but non-significant effect (72.2%), but rats injected with the high dose of scopolamine fell to a low of 52.8%, a rate which does not reliably differ from a random or chance rate, and which is significantly lower than the rates obtained after saline ($t=2.3$, $p<.05$) or atropine ($t=2.43$) injections.

Discussion

The present results show that scopolamine, at least at the higher dose of 1.2 mg/kg, profoundly disrupts spontaneous alternation in the rat. It is unlikely that this dose represents the threshold for this effect, but this is not known for certain, as intermediate doses were not used. The greater, though probably parallel effects of scopolamine, as compared to atropine, are probably due to the differences between the two in ability to penetrate the blood-brain barrier. The present results cannot be due to the peripheral effects of these drugs, as these are comparable for the two, but only in the case of scopolamine was the reduction in alternation pronounced.

Thus, the effects of scopolamine injections and hippocampal removal have once again been found to be similar. In both cases spontaneous alternation has been found to be reduced to rates very near the chance level. This adds further evidence to the effect that the abolition of theta activity in the hippocampus by this drug is an indicator of hippocampal

malfunction. Of course, it cannot be expected that the effects of hippocampectomy and scopolamine injections on behavior will be entirely similar, as the drug does much more than simply interfering with hippocampal function.

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The effects of prefeeding in plain and chained fixed ratio schedules of reinforcement¹

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The effects of prefeeding were studied using pigeons reinforced on either plain fixed ratio (FR) 64 or chained FR 32, FR 32 schedules of reinforcement. It was found that (1) the response rate increased as a function of the number of responses completed in the ratio, (2) the rate was higher for the chained FR group, (3) the rates decreased as a function of the amount prefed, (4) the latency of the first response in the ratio increased as a function of the amount prefed, (5) the prefeeding had a much greater effect on the rate in the first part than in the later part of the fixed ratio sequence, and (6) the prefeeding had a much greater effect on the response latency than on the response rate. It was concluded that the multiplicative rule of the effect of feeding schedules is inapplicable to behavior changes resulting from different segments of a single schedule of reinforcement.

Cumming, Berryman & Nevin (1965) indicate that response rate is a multiplicative function of the feeding schedule.² Stated symbolically,

$$R_i = C \times R_j,$$

where R is the response rate, i and j indicate two different feeding schedules, and C is a constant. This implies that the ratio of the two rates equals a constant,

$$\frac{R_i}{R_j} = C.$$

In other words, manipulation of a variable which affects the absolute value of the rates will leave the ratio unaffected;

$$\frac{R_{i,m}}{R_{j,m}} = \frac{R_{i,n}}{R_{j,n}} = C,$$

where m and n indicate two different values of some other variable. Cross multiplication results in the following "corollary": The ratio of the response rate obtained under two different conditions of one variable is unaffected by changes in the feeding schedule;

$$\frac{R_{i,m}}{R_{i,n}} = \frac{R_{j,m}}{R_{j,n}} = K.$$

Most of the experiments which Cumming, Berryman and Nevin review in support of the multiplicative rule involve the use of schedules of reinforcement as the other variable which is manipulated. A class of variables other than schedules of reinforcement which might be manipulated is the degree of similarity between test and

training stimuli in a stimulus generalization test; the rule does not seem to be applicable in that situation (Jenkins, Pascal, & Walker, 1958; Thomas & King, 1959). The present experiment is concerned with a test of the applicability of the multiplicative rule to the response rate in different segments of a single schedule of reinforcement; e.g. the first and last 16 responses of a fixed ratio 64 schedule of reinforcement.

Method

Eight Silver King pigeons at 70% ad lib weight and standard operant conditioning equipment were used. The chained fixed ratio (FR) group was exposed to the following schedule of food reinforcement: During the first component, S^- , the pigeon response key was dark until S waited for 30 sec. without responding. During the second component, S_2^+ , a horizontal white line was projected behind the key until the subject made 32 responses. During the final component, S_1^+ , a vertical white line was projected until the S made 32 more responses. Then the food magazine was presented for 3 sec. and the key was darkened. The schedule of reinforcement for the plain FR group was the same except that the S_2^+ component was eliminated and the number of responses required in the S_1^+ component was increased to 64.

After the behavior had stabilized, the testing phase was begun. For three sessions, the S s were not prefed, then for three sessions they were prefed 15 gm of food; and finally for three sessions, they were prefed 30 gm. Prefeeding was done 3 hr. prior to the session.

In addition to the usual cumulative response records, two other measures were obtained by the use of running time meters: (1) the average latency of the first response following the offset of S^- was recorded and (2) the 64 responses which intervene between S^- and the reinforcement were divided into four blocks of 16 responses and the average response rate was computed separately for each of the four blocks (actually the rate for the first block of responses was computed using responses 2 through 16 since it is not meaningful to include the time required for the completion of the first response following S^-).

Results and Discussion

Figure 1 shows that for both groups and all amounts of prefeeding, the response rate was a monotonically increasing function of the number of responses completed in the fixed ratio (cf. Thomas, 1964). For all blocks and all amounts of prefeeding, the response rate was higher for the chained than for the plain FR group; further research will be needed to determine the

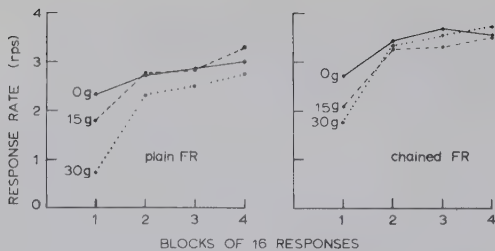


Fig. 1. Response rate as a function of the number of responses completed in the fixed ratio. For a given S, the mean response rate was computed for each block of 16 responses in the fixed ratio, and the median was then computed for each prefeeding phase. The medians of these data were then computed for each group and are shown in this figure.

variables responsible for the difference between this and earlier results (Thomas, 1964).

Although there was considerable overlap, the response rates clearly tended to decrease as the amount of prefeeding increased. That this is not apparent when examining only the cumulative response records may account for Sidman & Stebbins' (1954) failure to find similar effects.

It can be seen in Table 1 that the latency of the first response following S⁻ greatly increased as a function of the amount prefed (cf. Sidman & Stebbins, 1954).

The multiplicative rule predicts that the ratio of the response rates obtained under two different feeding schedules is a constant, independent of other variables affecting the response rate. This would seem to imply that the ratio of the rates under either the 15 or 30 gm prefeeding schedule to the rates under the zero gram schedule should be independent of the number of responses completed in the fixed ratio. That the ratio was not constant is shown in Fig. 2. The prefeeding had a much greater effect in the first part of the fixed ratio of responses.

Table 1. The median latency (sec.) of the first response following S⁻ as a function of the amount pre-fed and the schedule of reinforcement. For a given S, the median latency was computed for each prefeeding phase. The medians of these data were then computed for each group and are the unbracketed figures in this Table. The figures in brackets are the ratios of the adjacent latency divided by the latency obtained with 0 grams prefeeding.

Group	Amount Prefed (gm)		
	0	15	30
Plain FR	1.8	3.1 (1.8)	31.2 (17.7)
Chained FR	1.6	8.4 (5.2)	20.4 (12.5)

Since the latency of the response is a similar measure to the rate of the response, it might also be expected that the multiplicative rule would be applicable here. If it does hold then the ratio of the response rate to the latency should be independent of the amount of prefeeding. That this was not the case is readily apparent by examining Table 1 and Fig. 2. The response latency was much more affected by the prefeeding than was the response rate.

In conclusion, earlier research indicates that the multiplicative rule of the effect of the feeding schedule is applicable to rate changes resulting from changes in the schedule of reinforcement, but not resulting from changes in the degree of similarity between test and training stimuli in a stimulus generalization test. The present experiment indicates that the rule is also inapplicable to different segments of a single schedule of reinforcement.

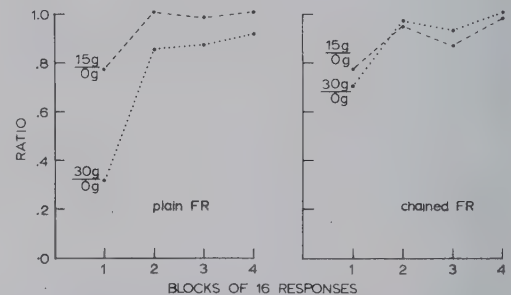


Fig. 2. Ratio of the response rates in the 15 and 30 gm prefeeding phases to the rates in the 0 gram prefeeding phase. These ratios are computed from the data shown in Fig. 1.

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Notes

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- The feeding schedule is a function of the hours of deprivation, percent of normal body weight, and amount of prefeeding. The empirical concept of "feeding schedule" is used in order to avoid the hypothetical concept of "drive strength" and the implication that manipulation of the three above mentioned variables will of logical necessity produce the same results.

An effect analogous to "frustration" on interval reinforcement schedules¹

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There are similarities between pigeons' behavior under interval reinforcement schedules and the behavior of rats in runways. A free-operant experiment analogous in certain respects to the double-runway procedure produced large "frustration effects" in pigeons, lending support to this comparison.

A previous experiment (Staddon, 1964) showed that exposure of pigeons to a reinforcement schedule in which the frequency of reinforcement varied cyclically as a function of time, induced a periodicity in their responding matching that of the schedule, but out of phase with it; i.e., the birds' maximum rate of responding coincided with reinforcement rate minima. This phase lag seems to be independent of absolute reinforcement rate, period of cycle and amplitude of cycle over a wide range.

There are similarities between this finding and the results of classical frustrative nonreward experiments (e.g., Amsel & Roussel, 1952; Bower, 1962). In the Amsel experiment rats ran to obtain food in a goal box at the end of a runway; after a fixed delay they were then allowed to run to a second goal box at the end of a second runway. When food was available in the second goal box on all trials, but in the first on only 50% of trials, running speed in the second runway was reliably higher following unrewarded trials in the first runway. This elevation in the response measure is the "frustration effect" (FE).

The parallel between cyclic schedules and the Amsel procedure is apparent if we consider the simplest cyclic situation, in which the schedule provides a short fixed-interval followed by a long fixed-interval followed by a short fixed-interval and so on in a repetitive sequence. Under these conditions the animal will respond most rapidly during the long fixed-intervals (i.e., when reinforcement rate is least) (cf., Skinner, 1938, p. 272). Ignoring for the moment the stimulus difference between the two runways, the two procedures may be compared thus: when reward is available in the first goal box, running in each runway corresponds to a short fixed-interval; when reward is only available in the second goal-box, running in runway 1 followed by running in runway 2 corresponds to a long fixed-interval. Hence the elevation in running speed in runway 2 following nonreward is analogous to the higher response rates found in the longer of the two fixed-intervals in the cyclic procedure.

In an attempt to explore this analogy a free-operant experiment similar in certain respects to the Amsel & Roussel procedure has been conducted. Instead of run-

ways, two identical fixed-interval schedules were used, presented alternately and separated by a "time out" (TO). The TO in our procedure corresponds both to the detention time in the first goal box and to the inter-trial interval, in the Amsel & Roussel experiment.

Method

The Ss were four male, White Carneaux pigeons, previously used in a variety of experiments and kept at 80% of their free-feeding weights.

The experimental chamber was a two-key box for pigeons made by the Grason-Stadler Co., with one key permanently covered. Effective responses produced an audible "feedback" click. The magazine aperture was illuminated during the presentation of grain and the house and key lights were turned off.

For most of the experiment 40 trials per day were given. A trial consisted of a 2-min. fixed-interval (component 1), TO (3.2 sec. darkness), 2-min. fixed-interval (component 2), TO (3.2 sec. darkness); with reinforcement (access to grain) during the first 3 sec. of every TO following component 2 and either every (continuous) or 50% (partial) of TOs following component 1. Responses were recorded as totals in each component over the session and, for component 2 (C-2), as totals following reward (C-2R) and nonreward (C-2N) in component 1 (C-1). Trial-by-trial data were recorded on a cumulative recorder and a printing counter.

The four experimental conditions to be discussed followed 10 conditions in which the TO duration was 30 sec.; this interval proved to be too long to produce reliable "frustration effects" in all four pigeons. During the next four conditions, when the TO duration was reduced to 3.2 sec., the variables manipulated were: (a) reward conditions in component 1: continuous vs. partial; and (b) stimulus conditions in the two components: both components signalled by the same stimulus (white key-light) vs. each component signalled by a different stimulus (red vs. green key-light). These conditions are summarized in Table 1.

Table 1. Order and duration of experimental conditions

Condition	Component 1 Stim Reward		Component 2 Stim Reward		Sessions
1	WL	cont	WL	cont	6
2	WL	part	WL	cont	11
3	RL	cont	GL	cont	3
4	RL	part	GL	cont	7

¹ RL and GL counterbalanced among the 4 pigeons

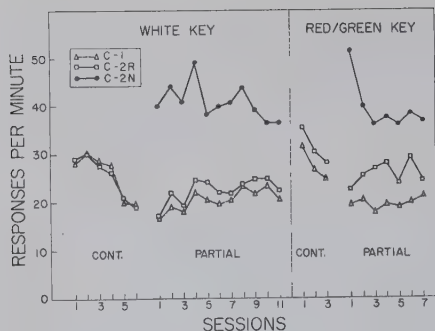


Fig. 1. Geometric means of the daily results for the four pigeons. Cont. and partial refer to the reward conditions in the first component.

Results and Discussion

Figure 1 shows the results of the four experimental conditions. In agreement both with Amsel and Roussel, and with the recent results of Davenport & Thompson (1965) in a similar situation, the major effect (shown by all four pigeons in both *partial* conditions) was a large elevation in response rate following nonreward. Cumulative records indicate that this effect is similar to the "running through" sometimes reported on both fixed-interval and fixed-ratio procedures; consequently, in terms of a "starting time" measure (e.g., latency to the first post-TO response), the magnitude of "FE" is even greater than the already large difference between C-2R and C-2N seen in Fig. 1.

A second effect, apparent in the mean curve and characteristic of three of the four birds, is that the FE in the second *partial* condition was highest on the first day and declined somewhat thereafter. These same three birds showed greater separation between C-1 and C-2R curves in the second than in the first *partial* condition; this difference is also reflected in the mean curves and is presumably the result of a discrimination between the *partial* and *continuous* components, made possible by the different stimuli associated with each in the last condition. The direction of this difference—higher response rate in the component associated with the higher reinforcement frequency—is in agreement with the results of Reynolds (1961) on multiple schedules. The first 10 conditions of this experiment, which showed a FE in only two of the four

birds, nevertheless demonstrated that the effects of both nonreward and discriminative stimuli are readily recoverable; it is possible, therefore, that the decline in FE following the first day of condition 4 is a reliable one, attributable to the stimulus difference between *continuous* and *partial* components.

The higher response rate in C-2R as compared to C-1 seen in condition 3 is largely attributable to a consistent green-preference shown by one of the pigeons throughout the experiment.

These results may be summarized as follows: (1) A comparison may be made between responding on cyclic interval schedules and behavior in a double-runway. (2) A fixed-interval procedure similar in certain respects to the double-runway situation produced large "frustration effects" in pigeons. (3) When the *continuous* and *partial* components of the procedure were signalled by different stimuli: (a) a discrimination developed between the two components; reflected in a higher response rate in C-2R than in C-1, in agreement with findings on multiple schedules; (b) the FE was highest on the first day of the *partial* condition and declined somewhat thereafter; this effect was probably also due to the development of a discrimination between the two components. (4) These results strengthen the comparison between cyclic schedule experiments and frustrative nonreward experiments; similarly, they imply a common behavioral mechanism between responding under interval schedules and behavior in runways.

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Note

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The apparent size of entoptic after-images

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Thirty-four male Ss made size and distance estimates of an after-image observed with closed eyes. Size estimates showed small variability, but distance estimates were highly inconsistent. To account for the consistent size estimates it is tentatively proposed that although the subjective impression is of boundless space, with eyes closed the sensory system acts as if the eyes are fixated at a finite rather than infinite distance.

Gibson (1950, p. 32) asserts that if "one observes an after-image against one's closed eyes or in absolute darkness, or against the cloudless sky it seems to float in what might be called an indefinite space. It does not seem to have any precise distance and likewise no precise size." Whilst Gibson's statement has an intuitive appeal, casual observations made during a study of Emmert's law gave the author the impression that after-images may have a definite appearance of size even when viewed with the eyes closed.

The present study was designed to see if Ss can make estimates of the apparent size and distance of an after-image when their eyes are closed and to see if these estimates are systematically related to properties of the inducing stimulus.

Subjects

Ss were 34 male students from an introductory psychology class who were screened on the Bausch and Lomb Orthorater and had an equivalent of 20/20 vision in their right eye.

Apparatus

The after-image including stimulus was a circle of 2-1/4 in. diameter lighted by a 24 v Grimes C-3A inter-aircraft control lamp fitted with a green filter. The lamp was located at a distance of 45 in. from S.

Procedure

Ss were tested individually and when seated were read the following instructions verbatim: "In this experiment I want you to use your right eye. Could you place this eye patch over your left eye?... Now will you look at the center of this circle (E points). I am going to shine a green light in your eye for a few seconds. It may feel a little unpleasant but it will not hurt your eye. (Light on for 30 sec.) Now close your eye (15 sec. pause). Can you see a green after-image? What is the diameter of the circle? How far away from you does it seem to be? (5 min. rest, during which time S took a color vision test). Now I want you to look at the center of the circle whilst I turn the light on again. (Light on 30 sec.) Now close your eye. (15 sec. pause.) Now will you ignore the after-image and tell me the diameter of the green light you were just looking at when your eyes were open. How far away from you did it seem to be?"

Results and Discussion

All estimates of diameter of the after-image were given in fractions of an inch, "one-quarter of an inch" being the most common response ($N=21$). The mean estimate of diameter was 0.27 in. ($\sigma=0.13$). Distance responses for the after-image were made either in inches ($N=16$) or feet ($N=18$). As this is a clear difference in response, separate analyses of data were made for "inches" (I) and "feet" (F) distance responses. Table 1 lists the means and standard deviations for size (diam.) and distance for both groups. A t -test between the mean diameters of after-images for groups I and F was not significant ($t=1.00$, $df=32$). Thus the present results indicate that naive Ss can consistently estimate the apparent size of the after-image although the estimates of apparent distance fall into two distinct clusters. This raises the question as to how these results may be related to properties of the inducing stimulus.

The mean estimate of diameter of the after-image inducing stimulus was 2.43 in. ($\sigma=0.58$) and the mean distance away was 3.74 ft. ($\sigma=0.73$). As the real diameter was 2.25 in. and the real distance 3.75 ft., these estimates corresponded closely to the veridical values. From these results it is clear that Ss were not making estimates of the size of the after-image by giving the apparent diameter of the inducing stimulus they had just observed. For group F a t -test (related samples) comparing the means of after-image distance and means of inducing stimulus distance estimates was not significant ($t=1.13$, $df=17$). Thus although size estimates were not influenced directly by the apparent size of the inducing stimulus, just over half the distance estimates were not significantly different from the apparent distance of the inducing stimulus.

The ratio of the distance of the inducing stimulus to its diameter is 20:1. Using apparent estimates the mean ratio is 18.32:1 ($\sigma=4.10$). For group I the mean ratio is 15.02:1 ($\sigma=15.31$) and for group F the mean ratio is 452.66:1 ($\sigma=890.60$). Thus Ss' estimates do not conform to Emmert's law of apparent sizes (Price, 1961).

The hypothesis that estimates are only reflecting habitual response tendencies seems unlikely in view of the consistency with which Ss made size estimates.

Table 1. Mean and standard deviations of diameter and distance estimates for groups I and F.

	Group I (N=16)		Group F (N=18)	
	$\bar{x}$	σ	$\bar{x}$	σ
Diameter	0.29 in.	0.16	0.25 in.	0.10
Distance	3.45 in.	2.66	6.17 ft.	2.85

Nevertheless in order to obtain some data on response tendencies, 66 male students were given the following instructions: "I want you to close your eyes and imagine you see a disk. (Pause.) Now estimate its diameter. Keep your eyes closed. Now estimate how far away from you this imaginary disk appears to be." Fifty-three Ss gave estimates of diameter in inches, the mean value being 6.06 in. ($\sigma = 4.33$). With the exception of 8 Ss, distance estimates were in feet, the mean value being 11.21 ft. ($\sigma = 24.37$). The other 13 Ss gave estimates of both diameter and distance in feet. Hence it appears that responses in the presence of the after-image were not a simple reflection of habitual response tendencies.

The following is proposed as a tentative and speculative explanation for the relatively consistent size estimates and wide range of distance estimates obtained: With closed eyes the visual scene lacks apparent depth and has the appearance of "infinite" or unbounded space. Nevertheless it could be assumed that in this state the eyes are fixated at some distance, but in the absence of "psychological" cues the S's perceptual

system may process information about the after-image as if it were projected at the plane corresponding to the fixated distance. If it is further assumed that the fixated distance for closed eyes is a relatively stable property of the sensory system then consistency in size estimates from S to S is explicable. On these assumptions the distance at which the eye is fixated could be extracted from the data assuming Emmert's law to hold for "real" rather than apparent distance (Young 1951). For the present inducing stimulus a diameter estimate of 1/4 in. could be expected from a projection plane at 5 in. Further research is in progress to test this inference.

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Note

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Human eyelid conditioning at detection threshold

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Six Ss were run in a combined signal detection-eyelid conditioning procedure for 15 days each. Performance at asymptote was markedly affected by CS intensities near the detection threshold. The verbal responses and conditioned responses were related in such a way that conditioned responses appeared to be contingent upon Ss' subsequent verbal responses.

In the Pavlovian conditioning situation, three of the most obvious variables which may control performance are the intensity of the conditioned stimulus (CS), the intensity of the unconditioned stimulus (UCS), and the time interval separating them. These parameters have received extensive manipulation, with humans, and the latter two (UCS intensity, and CS-UCS interval) have consistently been found to have marked effects, whereas CS intensity variations have had far less dramatic effects (e.g., Walker, 1960; Beck, 1963; Grice & Hunter, 1964). An examination of these and other studies indicates that relatively high CS intensities have exclusively been used. This is surprising in light of the formulations of Pavlov (1927) and Hull (1952) that minimal or no conditioning should occur with very weak CSs.

One reason for the range of CS intensities selected in the above studies is the limitations set by the procedures adopted, e.g., CSs presented through loudspeakers, untrained subjects. The CS intensity limitations of these procedures can be overcome by utilizing other techniques. One such technique, which we have adopted, is readily suited to determine the effects of very weak CSs—combining a signal detection procedure with an eyelid conditioning procedure and utilizing the Ss' verbal responses to determine CS intensity. This technique also offers a bonus in that the relationship between verbal and conditioned responses (CRs) as indicators of signal detection can be evaluated.

Method

Six paid volunteer male undergraduates were run as Ss. Four of the Ss were run for 15 daily sessions, the first three of which were practice sessions, and the last 12, test sessions. The remaining two Ss had been previously run in a similar experiment and were well practiced. They served in one practice session and the final six test sessions.

The procedure consisted of a combination of signal detection and eyelid conditioning experiments. The Ss wore earphones with a 65 db above threshold (method of limits) white noise (0-20KC) continuously present. Every 10, 15, or 20 sec., a 250 msec. one pound per square inch air puff was delivered to the cornea of their right eye for a total of 180 puffs per session. Ss were instructed to keep looking at a fixation point on the wall in front of them, and when they felt the air puff to state whether the CS-tone immediately preceded it. The CS (1KC) when presented, commenced 525 msec. prior to the air puff, and terminated with air puff termination. Three tone intensities—0 db, i.e., detection threshold (50% detection of the CS with fewer than 1% false positives), 2.5 db above detection threshold, and 12 db above detection threshold and three tone presentation probabilities—25%, 50%, and 75%, were used. For example, on Day 2 of the test sessions (see Fig. 1 and Table 1) Ss received 180 air puffs, 135 of them preceded by tones, to only approximately 67 of which they reported a detection. False positives were discouraged in the practice sessions, and as a consequence, over the test sessions in which 0 db tone was used, fewer than .5% occurred.

During the 525 msec. period preceding the air puff presentation, eyelid movements were recorded. Responses which were 2 mm or greater, and occurring in the interval from air puff onset to 375 msec. prior to air puff onset were scored as CRs. On CS trials, this was the interval 150 msec. after CS onset to air puff onset.

Results and Discussion

The results from this experiment can be seen in Table 1 and Fig. 1. The group means are presented in Fig. 1, and the individual data in Table 1. "Tone-Yes" (To Y) represents those trials on which a tone was presented and the S reported a detection; "Tone-No" (To N) represents those trials on which the tone was presented and the S reported a non-detection; "No Tone-No" (NTon) represents those trials on which the tone was not presented and the S reported a non-detection.

Table 1. Percentage CRs for each subject for the twelve test sessions

	Day1 75%T +12db			Day2 75%T 0db			Day3 50%T +12db			Day4 50%T 0db			Day5 50%T +2.5db			Day6 75%T +2.5db		
	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon
RA	23.7		2.2	6.8	4.7	2.4	25.6		3.3	0	4.0	3.5	8.3		4.7	7.0		4.5
DC	97.8		6.7	31.6	12.3	9.8	83.3		12.2	21.1	11.6	13.4	71.8		11.5	67.2		13.3
WC	99.3		4.4	21.2	4.8	4.9	77.8		2.2	22.5	8.3	1.4	64.7		12.6	61.8		20.9
NG	40.0		3.3	15.7	10.0	4.7	75.6		6.7	9.4	7.5	11.8	34.1		4.5	48.4		11.4
	Day7 50%T +12db			Day8 50%T 0db			Day9 75%T 0db			Day10 75%T +12db			Day11 25%T 0db			Day12 25%T +12db		
	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon	To Y	To N	NTon
RA	62.2		3.3	9.4	7.4	4.8	22.4	3.2	0	82.2		0	10.5	4.5	6.6	86.7		8.1
DC	88.9		13.3	47.1	22.4	15.3	52.9	16.6	20.0	88.9		13.3	52.6	14.2	17.4	91.1		15.6
WC	66.7		12.2	37.0	12.5	7.6	21.9	25.4	21.6	95.6		17.8	22.2	14.2	11.5	86.7		8.9
NG	84.4		5.6	15.4	11.1	9.4	10.2	5.7	0	89.6		8.9	21.7	5.5	3.3	93.3		11.9
SJ	87.8		13.3	34.7	23.5	17.4	21.2	10.2	8.3	69.6		8.9	36.4	26.3	16.5	80.0		14.8
HW	44.4		16.7	15.2	7.8	9.3	10.0	15.4	9.3	69.6		22.2	17.6	14.2	21.9	60.0		17.8

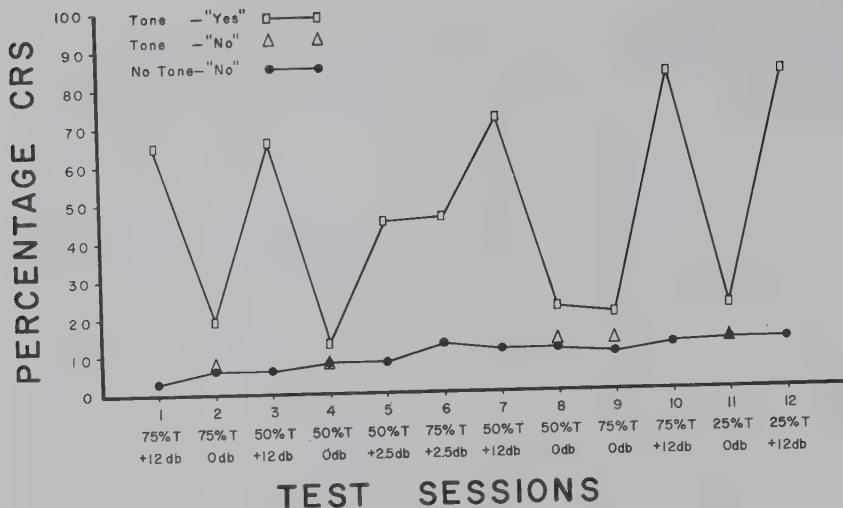


Fig. 1. Percentage conditioned response during each test session as a combined function of signal presentation and verbal response.

Observation of Fig. 1 and Table 1 indicates that both group and individual data were stable across the test sessions. Only one S (RA) showed any marked variability, but his performance was stable within the first and last six session blocks.

With regard to CS intensity effects, the salient finding was that small variations in CS intensity had marked effects on performance which were independent of order of intensity presentation and of CS presentation probability. The latter finding indicates that performance differences as a function of CS intensity were not caused by differences in the number of detected CSs between high and low CS intensity sessions. Examination of the within-session data showed no systematic performance shifts. Thus, performance changes from session to session were rather immediate. Subtracting CR probability on "No Tone-No" trials from "Tone-Yes" trials, which indicates percentage CRS above base level of responding, and averaging across sessions, Ss made approximately 12% CRS on 0 db sessions, 35% CRS on 2.5 db sessions, and 64% on 12 db sessions. (Examination of Fig. 1 and Table 1, indicates that (with two exceptions in Table 1 involving 0 db and 2.5 db comparisons) there was no overlap between performance to these intensities, and that performance to a given intensity was stable across sessions. Relative to the previous human eyelid conditioning work on CS intensity effects where 50 db CS differences yielded at most 35% differences in conditioning the present results were striking, where differences of 2.5 db and 12 db yielded 23% and 54% differences, respectively. This marked diminution in responding as the detection-threshold is approached strongly supports the Pavlovian and Hullian formulations.

With regard to the relationship between verbal and conditioned responses, the following paradoxical conclusion is suggested: That the elicitation of a CR

appears to be dependent upon the S's subsequent verbal report as to whether or not he heard the tone. The following observations support this view: Percentage CRS when the tone was presented and the S reported a detection was far less than 100%; percentage CRS when the tone was presented and the S reported a non-detection was the same as when the tone was not presented and the S reported a non-detection.

If we assume that our Ss adopted a high criterion for the verbal detection response (Ss had a strong bias to say "No") (Swets, Tanner, & Birdsall, 1961; Luce, 1963), and further that CR elicitation was not a function of the verbal response, but rather of signal presentation, then more CRS would have been given on "Tone-No" trials than on "No Tone-No" trials. This was clearly not the case. It can not be the case that the CR produced the verbal response because more "Yes's" to the tone were given than CRS. One explanation of these phenomena is that the decision criterion a S selects (response bias) affects both verbal and conditioned responses.

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Note

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Human successive discrimination reversal: Effects of overtraining and reinforcement

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The overtraining reversal effect (ORE) was found in a human successive discrimination task. Two types of reinforcement were used, with three levels of training on the original problem. The ORE appeared with the first level of overtraining and then became practically asymptotic with additional overtraining.

A recent review of the effect of overtraining on habit reversals in rats (Paul, 1965), reports 13 published experiments showing a facilitative effect of overtraining on reversal, and 19 published experiments which fail to show facilitation. Paul reports that the weight of evidence suggests that the overtraining reversal effect (ORE) is more likely to be found for visual discrimination tasks than for spatial or position discrimination tasks.

There have been only a few investigations of the ORE with human Ss. One of these examined the effect of overtraining and delay on the learning of a spatial reversal in children 6 to 8 years of age (Stevenson & Weir, 1959). They found that overtraining had no facilitory effect on reversal; however, delay did facilitate reversal (as measured by number of trials to a criterion of six correct). The authors suggest that overtraining has the greatest effect when motivation is low, and that throughout their experiment, the children enjoyed the task and were highly motivated to please the experimenter.

Youniss & Furth (1964) report an experiment designed to replicate, in part, the study by Stevenson and Weir. Instead of spatial responses, they used one-digit numbers as the response to colored stimuli cards. The Ss were, third grade students. The results showed that both overtraining and delay facilitated reversal of the original task. The authors interpret the facilitation of overtraining according to the discriminable change hypothesis (Capaldi & Stevenson, 1957), that is, with overtraining, the reinforcement change following reversal was more clearly discriminable for the overtrained groups than when reversal followed criterial training.

Some doubt remains concerning the parameters influencing the occurrence of the ORE. It appears that the nature of the task, reinforcement, and the type of species examined are factors which may influence the presence of a facilitory effect of overtraining on reversal. A task of discriminating the oddness or evenness of digit pairs was chosen in order to increase the difficulty for the S, so that the task would not be learned too quickly, thus precluding the appearance of the ORE.

Two conditions of reinforcement were utilized, one with only a positive reinforcer, and the second with both positive and negative reinforcers.

Subjects

The Ss were 79 experimentally naive students enrolled at the University of Arizona. Of the total, 25 did not reach the acquisition criterion within 100 trials and were eliminated for failure to learn the original task. The remaining 54 Ss (31 females and 23 males) had a mean age of 20.2 years (range 17 to 37 years).

Apparatus

The Bisenory Unilateral Response Processor (BURP), described by Chambers & Bartlett (1962), is an electronic logic device capable of presenting a series of stimuli in a pre-programmed sequence of order and interval. Connected to the BURP was an aluminum subject display panel, through which shone two miniature Nixie tubes (.5 in. diameter, Model 7009) horizontally separated by 1.75 in. These Nixie tubes presented randomized pairs of digits, either odd (11, 33, 13, 31) or even (22, 44, 24, 42), controlled in stepping rate by E. A 1 in. diameter green jewel reinforcement light, was flush mounted on the top of the display panel. The buzzer, a Kiho electric horn (No. 1390), of presumed noxious tone, was mounted behind the display panel.

The S, isolated from E, was seated in a small air conditioned, sound proof room. A one-way window allowed E to continually observe S, and an intercommunication system allowed E to monitor S while allowing "push-to-talk" capability for E.

Procedure

There were two reinforcement groups: Group No-Buzzer (NB) (N=36), which had a green light presented following a correct response only; and Group Buzzer (B) (N=18) which had a green light presented following a correct response and a buzzer presented following an incorrect response. Each group was divided into three treatment groups corresponding to the levels of acquisition training on the original task: Criterion (C) which required 8 out of 10 responses correct, Overtraining A (OTa) which required 13 out of 15 responses correct, and Overtraining B (OTb) requiring 18 out of 20 responses correct.

In the original acquisition, the verbal response "right" was positively reinforced for the even pairs, and "left" for the odd pairs, for one-half of the Ss; the other half received the opposite reinforcement contingency. In effect, the data indicated that the overtraining groups could be considered as C plus 5 cor-

rect responses and C plus 10 correct responses. Upon completion of the original acquisition phase, the task was reversed (response "right" was reinforced for the odd pairs and "left" for the even pairs) and the number of trials to correct consistent reversal (first correct response in the series of 18 out of 20 correct responses) was recorded.

At the beginning of the experimental session, the Ss were read a standard set of instructions. The instructions informed the Ss that there was something about the pair of digits that would "tell" them to make a verbal response of "right" or "left," that it was possible to make a correct choice for every pair, and that they were to make as many correct choices as they possibly could.

Following a correct response, the green reinforcement light was turned on, and remained on until the next stimulus pair was presented. For Group B, the buzzer remained on after an incorrect response for 3 sec. The stimuli remained on until the S made a response, and there were 12 sec. between stimuli during which time the E recorded the response on preprinted data sheets.

Results and Discussion

The primary data were the number of trials to reversal as a function of the type of reinforcement and the three levels of training. Figure 1 graphically shows

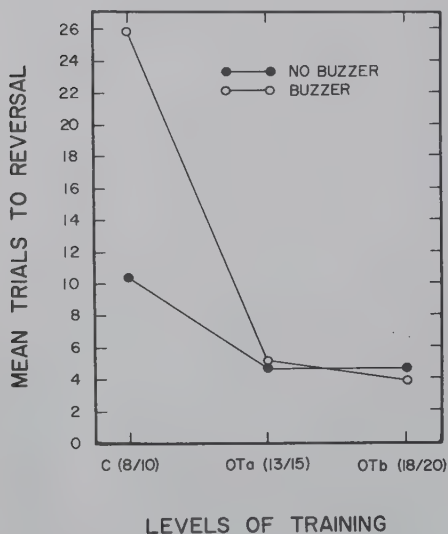


Fig. 1. Mean number of trials to correct reversal as a function of level of training and type of reinforcement.

the mean number of trials to correct reversal as a function of the level of training and the presence or absence of the buzzer. A 2 by 3 analysis of variance showed that the effect of the levels of training was significant ($p < .001$), as was the reinforcement group effect and the level of training by group interaction ($p < .05$).

Orthogonal comparisons were used to independently test the effect of the levels of training on each of the reinforcement groups. The criterion vs. overtrained groups comparison was significant for both Group NB and B ($p < .01$). The OTa vs. OTb comparison was not significant for either reinforcement group.

The results showed that fewer trials were required to learn the reversal with overtraining than with criterial training. No increased facilitation occurred with increased overtraining within the overtraining limits examined. It may be concluded, that for this study, utilizing a successive discrimination with adult humans, overtraining did facilitate reversal learning up to a point. Beyond this point, further overtraining had no facilitative effects upon reversal.

While the type of reinforcement was a significant variable, this appeared mainly to be due to a decrement in reversal performance for Group B at the criterion level of training. The presence or absence of the buzzer had little or no effect on the overtrained groups. How much importance should be placed upon this finding is open to question. It does point out, however, that the nature of the reinforcement does play a part in the ORE, and that its effect may not be constant for all levels of training. Likewise, it does not appear unlikely that nature of the reinforcer may be responsible for the lack of appearance of the ORE in studies which have failed to find overtraining facilitation in reversal situations.

On the basis of the post-experiment verbal reports of the Ss, the ORE appears to be due to the fact that Ss at the end of criterial training are sampling a larger cue population than Ss after higher levels of training. In effect, the overtrained Ss have eliminated a greater number of possible solutions to the problem and are better able to note the change in reward contingencies at the onset of the reversal training.

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Transfer of interitem associations from serial to paired-associate learning¹

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Transfer of interitem associations from a serial to a paired-associate (PA) list was investigated. Two serial and two PA lists were used. All lists were constructed from consonant-vowel-consonant trigrams matched for meaningfulness and arranged so as to minimize intralist variability. In the experimental condition S learned a PA list constructed from adjacent items on a previously learned serial list. In the control condition the irrelevant PA list was learned. No differences in trials to learn the two PA lists were found. The results of the present experiment replicate previous transfer studies in which such lists were constructed of adjectives. An interitem association theory of serial learning is not supported.

To clarify the nature of the effective stimulus in serial learning, Horowitz & Izawa (1963) investigated transfer from serial to PA learning when the transfer measure was based on a comparison between two groups. The first group learned a serial list followed by a PA list. Ss in the second group learned only the PA list. Horowitz and Izawa obtained positive transfer from serial to PA lists. However, the measure of transfer was based on a comparison of a group which had previously learned a serial list with one which had had no previous experience. As Young & Casey (1964) point out, the results of Horowitz and Izawa may be either a function of interitem associations formed during previous serial learning, or they may simply reflect a differential practice effect which would, of course, confound any interpretation of the results.

Young (1961, 1962) and Young & Casey (1964) have found that PA learning following relevant serial learning does not differ from PA learning following irrelevant serial learning. A relevant PA list was defined as constructed from adjacent items on the previously learned serial list. An irrelevant PA list was defined as having been constructed from a serial list with which S had had no previous experience. The lists used in these experiments were made up of adjectives. In Young & Casey's (1964) study the adjectives were taken from the condition of the Horowitz & Izawa (1963) experiment which yielded the greatest positive transfer. Although in all these experiments the intralist similarity and similarity between sets of lists were held as low as possible, adjectives may have a considerably different association value and meaning for individual Ss. This difference of association value may produce inconsistent intralist variability.

The present experiment has attempted to reduce this source of intralist variation by using CVCs having

approximately equal value on Noble's (1961) meaningfulness scale.

Method

Twenty Ss, 10 in each of two conditions, participated in the experiment. Although 26 Ss were tested, six Ss failed to reach criterion in PA learning. Of these six Ss, three had been assigned to relevant PA learning and three had been assigned to irrelevant PA learning. All Ss were students enrolled in an introductory psychology course at Eastern Washington State College and had been awarded 10 points for participation in the experiment. None of the Ss had had previous experience in verbal learning experiments.

Twenty syllables were selected from Noble's (1961) list of CVCs. The syllables ranged from 2.02 to 2.19 on Noble's meaningfulness (m') scale. Two serial lists containing 10 syllables each were constructed following the conventional rules set by Hilgard (1951). Each list had an approximately equal distribution of scale valued syllables. An asterisk placed before the first syllable of each list served as the anticipation signal. Two nine-pair PA lists composed of adjacent items on the respective serial lists were used in PA learning. A Lafayette memory drum was used to present the lists.

This experiment consisted of two phases: a serial learning phase, and a PA learning phase. In the serial learning phase, each S was required to learn one of two 10-item serial lists to a criterion of one perfect trial. In the PA learning phase, each S was required to learn either a relevant or irrelevant PA list.

The design of this experiment was a 2 by 2 factorial. In the first phase, Ss were randomly given one of two serial lists. In the second phase, Ss were again given one of the two PA lists. This design reduces to two basic conditions; half the Ss were exposed to a PA list after relevant serial learning and the other half were exposed to a PA list after irrelevant serial learning.

The PA lists had been constructed from adjacent syllables on the respective serial lists. That is, items A, B, and C of the serial lists were combined to form PA items A-B and B-C. This process was continued throughout each serial list until each item, except the first and last, were used as both a stimulus and a response in the PA list. The first item, of course, acted only as a stimulus and the last item acted only as a response. The order of the pairs in the list was changed from trial to trial.

All lists were learned by the anticipation method to a criterion of one perfect trial. Approximately 3 min.

separated the learning of the serial and PA lists to permit giving PA instructions. An exposure time of 2 sec. and an intertrial interval of 6 sec. was used in the presentation of both the serial and PA lists.

The E has found through previous experience that continuation beyond approximately 57 trials results in severe S fatigue. Therefore, if an S had not learned the PA list within 57 trials he/she was rejected.

Results

The means and standard deviations of trials to criterion for each serial list were: SL1, $M=21.9$, $SD=8.10$; and SL2, $M=22.2$, $SD=7.77$. As can be seen, the two serial lists may be considered to be of equivalent difficulty and homogeneity of variance can be assumed.

The means and standard deviations of trials to criterion for relevant and irrelevant PA learning were: Relevant PA, $M=24.4$, $SD=13.58$; Irrelevant PA, $M=28.1$, $SD=11.94$. Although no significant differences were found, the differences between the means was in the direction predicted by an S-R chaining (i.e. interitem association) hypothesis.

Learning of individual items on the PA lists as a function of serial position on the relevant serial list was also analyzed. No serial position effect was found to exist.

Discussion

The results of the present study do not support a theory of positive transfer of interitem associations from serial to PA learning. They do replicate the results of previous investigations by Young (1961,

1962) and Young & Casey (1964) and lend further support to Young and Casey's contention that the positive transfer observed by Horowitz & Izawa (1963) was due to practice effects.

Apparently CVCs matched for meaningfulness are equivalent to adjectives as used for this task by Young (1961, 1962) and Young & Casey (1964). Either the hypothesized intralist variation does not exist in the Young and Young and Casey studies, or the effects of it have been eliminated by randomization.

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Notes

1. This report is based on a paper read at the Fifty-first Annual Meeting of the Kentucky Academy of Science, University of Kentucky, 1965.
2. Now at the Wenner-Gren Aeronautical Research Lab. University of Kentucky, Lexington, Kentucky.

Perceived slant as a function of direction of regard¹

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Four groups of Ss viewed trapezoid shaped transparencies in a tachistoscopic device. Each group estimated that slant of the stimulus when it was photographed. Two groups looked up at the transparencies, two down. The results indicated that direction of regard alone was insufficient to influence the perceived slant. As in previous studies, relative midpoint height of the vertical edges of the trapezoid was a depth cue as was end ratio. The results were considered in terms of muscle involvement and shape invariance hypothesis.

If a rectangle is rotated about its vertical axis, its two dimensional projection will be a trapezoid with one vertical end shorter than the other. If the rectangle is viewed from above, the midpoint of the shorter end will be higher in the picture plane than the midpoint of the longer end. If viewed from the bottom, the opposite is true (Dunn, Grey, & Thompson, 1965). This relative difference in midpoint height was called RMH by Dunn & Thomas (1965). It was defined as "the height of the shorter-end midpoint minus the height of the longer-end midpoint." They found that if Ss looked straight ahead at photographs of trapezoids, those with a high-positive RMH value were generally seen as more slanted than those with a low-positive or negative RMH value.

From the results above, it would appear that the Ss responded as if the rectangles were below them. The question of how they would respond if they were to look up at the same stimuli then arises. If the Ss perceived the rectangles as above them, their experience with stimuli so positioned might be expected to reverse the effect described above. Looking down, on the other hand, might be expected to enhance the effect found earlier since the viewing position depicted by the camera and the kinesthetic cues could be in better agreement for the high-positive RMH cues. Such an explanation seems to be a logical deduction from the sensory-tonic theory of perception (Werner & Wapner, 1952).

Subjects

The Ss were 64 psychology students at the University of Minnesota, Morris.

Apparatus

The apparatus consisted of eight trapezoidal transparencies, one rectangular transparency, and a tachistoscopic device, all of which have been described in detail elsewhere (Dunn & Thomas, 1965). Four of the transparencies had end ratios of 15:16 and four of 13:16. In each group of four, two had absolute RMH differences of 24.5' of arc (visual angle) and two had differences of 44.1' of arc. Each transparency could be placed in the tachistoscope so as to have either a

positive or negative RMH value. Each could be placed in the apparatus with its shorter edge to the left or right of the observer. All stimuli were of the same length, and the height of the longer edge was the same for all stimuli. The rectangle was also of the same length (4°46' of arc) and was of the same height as the longer end of the trapezoids (2°23' of arc).

The response of the S was measured by the pivoting of a rod around a right-end vertical axis. S moved it to a slant which appeared equivalent to the slant of the stimulus presented to him (see Dunn & Thomas, 1965).

The tachistoscope could be sloped at any one of the four angles, forcing S to look either up or down at the stimulus. The angles were: -20-1/2° (D-); -10-2/3° (D); 10-2/3° (U); 20-1/2° (U+).

Procedure

A 4 by 4 by 2 by 2 Latin square design was used. Sixteen Ss were run in each of the four directions of view. Each S was presented with all 16 combinations of the four RMH values (-44.1', -24.5', 24.5', 44.1'), the two end-ratio conditions, and the two left right positions of the long end of the trapezoid. These were presented in the same Latin square to each group (D-, D, U, & D+).

Stimulus presentations were made in the following manner: 10-sec. presentation of the trapezoid, 30-sec. response and rest period, repeat cycle. All stimuli were responded to including the rectangle.

The Ss were instructed to respond to the way the stimuli appeared rather than to their calculated estimate of the slant by use of the rod. If the S felt that there was a discrepancy between the way the stimulus appeared and the way he thought it was actually oriented, he was permitted to make a second response, which did not count. Initial instructions were given by showing S a swinging door opened both ways and indicating to him how slanted it was by use of the rod.

Results

An analysis of variance was performed. Since the F-score for sequences and square uniqueness were less than one, the author did not use Box's (1953) correction as Dunn & Thompson (1965) did when using a single Latin Square. As suggested by Grant (1948), the residual and square uniqueness components were combined to form a single error term for all within Ss effects having 840 degrees of freedom. Between Ss effects were tested by the significant ($F=4.83$ with 45 degrees of freedom; $p < .01$) Ss/sequences.

Directions by trials was the only significant effect involving direction of view ($F=1.60$ with 45 degrees of

Table 1. Mean Perceived Slant in Degrees

Direction of View		D--			D			U			U+			Row Averages		
	Ratio	15:16	13:16	Av.	15:16	13:16	Av.	15:16	13:16	Av.	15:16	13:16	Av.	15:16	13:16	Av.
RMH																
44.1°		16.7	22.0	19.3	16.0	16.9	16.4	6.3	15.6	11.0	17.1	21.5	19.3	14.0	19.0	16.5
24.1°		16.3	17.9	17.1	10.3	15.0	12.7	8.3	18.1	13.3	13.2	21.0	17.1	12.0	18.0	15.0
-24.5°		7.4	9.0	8.2	5.9	12.2	9.1	3.8	6.8	5.3	8.6	19.2	13.9	6.4	11.8	9.1
-44.1°		1.0	11.9	6.5	5.9	12.2	9.1	3.3	8.1	5.7	7.9	18.5	13.3	4.5	12.7	8.6
Column Average		10.4	15.2	12.8	9.5	14.1	11.8	5.4	12.2	8.7	11.7	20.0	15.9	9.2	15.4	12.3

freedom; $p < .01$). Both the direction main effect and its interaction with treatments did not reach significance. The component of variance which contributed to the significant interaction was the linear $\times$ linear interaction. The F -score with one degree of freedom was 17.20 ($p < .01$). However, the only slope that was itself significantly greater than zero was the slope for the D- group. An F -score (one degree of freedom) of 13.38 was obtained ($p < .95^{1/4}$). The reduction in score seems to be slightly greater with negative RMH values, but this cannot be clearly shown, statistically. In general, as Table 1 shows, the negative RMH values were seen as less slanted than the positive values. That the difference was significant ($F = 14.21$ with 3 degrees of freedom; $p < .01$) post-anova test, the studentized range statistic, indicated that the responses to the positive RMH values were significantly different ($p < .05$) from the negative values, but some signed RMH levels were not significantly different from each other. This same result was found when the two different end-ratios were analyzed separately.

A significant effect of direction of orientation of the trapezoid was found ($F = 4.91$ with one degree of freedom; $p < .05$). When the short end was to S's left, his average slant was 13.4° and when to this right, 10.9° .

Discussion

The results support two earlier studies (Dunn, 1965; Dunn & Thomas, 1965), but do not support the hypothesis that upward viewing reverses the RMH effect found in these studies. Certainly the data does not strongly suggest that the muscle involvement of looking up will reverse the RMH effect. Dunn, Grey, & Thompson (1965) have discussed possible responses of an S to stimuli above him, but on a plane extending below his eye level. The responses, they showed, would be predicted to be similar to those given when S was actually looking down at the stimulus from above. If in the absence of a plane, S judged the object with respect to an imaginary plane extending below his eye level, the results of this study are easily explained.

Little need be said about the significant effect of different end-ratios ($F = 36.24$ with one degree of freedom;

$p < .01$). Such findings are typical of most trapezoidal studies of slant.

The effect of orientation of stimuli has been found before (Nixon, 1965), however, subsequent alterations in the apparatus changed the direction indicating that such a result may be easily produced by asymmetries in the apparatus. On the other hand, the findings of Gaffron (1962) which showed that the left side of a picture seems to have more depth than the right for right-eye dominant people might indicate that such a result may have been more than an apparatus artifact.

The findings of this study and the earlier studies (Dunn, 1965; Dunn & Thomas, 1965) have distinct implications for the invariance hypothesis. Unless S viewed each stimulus object of a different RMH value as having a different shape unslanted, he would be indicating several different degrees of perceived slant for a similarly shaped figure with equal end-ratios. That the Ss actually did this is indicated by the similarity of these results to those of Dunn & Thomas (1965) where the Ss were instructed that they were looking at slanted rectangles.

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Note

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After-image fusion¹

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A new aspect of the complex of after-image phenomena is described. It consists of the appearance of lines connecting initially separated after-images, if they are observed against a flickering background. These lines appear during the fading of the after-image. The after-images were produced by various configurations of Xenon flashes, the flickering background by a standard photostimulator. The phenomena was called after-image fusion not to be confused with binocular fusion. The report is qualitative. The main conclusion reached is the actual existence of the fusion phenomenon. Possible influences of conditioning or suggesting were debated and thought of small importance. The phenomenon casts some doubts on the simple mechanistic retinal origin of the after-images.

From antiquity Aristotle and later Goethe, Newton, and Descartes were intrigued by the fact that visual activity continues after retinal stimulation has ceased. Purkinje is considered to have been the first to study after-images comprehensively using the tools of modern physiologic investigation. In spite of the amount of information gathered about after-images and allied phenomena, little is known about their mechanism, and even the site of their formation is disputed. Since Craik, the consensus is that they are of retinal origin. Howard, however, demonstrated a phenomenon indicating a central component.

While working routinely with after-images, a new phenomenon has been discovered which could not be found described in the general literature. Essentially, this phenomenon consists of the perception of lines connecting separate but simultaneously produced after-images observed against a flickering background. For simplicity, this phenomenon has been called fusion of the after-image; not to be confused with binocular fusion. The present report covers a qualitative study of this new aspect of the after-image.

Method

The experiments were conducted in a room with walls evenly painted a light green. A Grass photostimulator (Model PS2) was the only source of illumination in the room while observing the fusion. This photostimulator set at a frequency of 11 flashes per sec. and at its output intensity of 4 (arbitrary scale on Model PS2) provided a flickering field.

Two types of flash-stimulators were used to produce the after-images. The first consisted of a conventional linear electronic flash tube 32 cm long with a 7 mm quartz body. It was powered by a 23.4 mfd capacitor charged to 2000 volts. Flashes of variable lengths, separated by variable gap sizes, were obtained by adequately masking this tube with black tape (Fig. 1). The second flash stimulator consisted of four con-



Fig. 1. Linear electronic flash stimulator covered with black tape to produce variable stimuli.

ventional helicoidal flash tubes attached to the back of a board. Their light output was limited by 2.5 cm ϕ holes arranged at the corners of a 15 cm square. Each flash was powered by 1100 mfd charged to 450 volts wired to ignite simultaneously. Light was diffused by inserting a paper screen between the board and the flash tubes. Various patterns of flash stimuli were obtained by covering the holes with black tape.

A procedure was standardized as follows: For the first part of the experiment, the linear electronic flash stimulator was placed 60 cm from a wall, while the S, sitting 150 cm from this wall, was instructed to fixate monocularly (with the other eye covered) at the middle of the black tape in the center of the flash stimulator. The photostimulator, placed 50 cm behind the S, was aimed at the wall in front of the S. Immediately after the flash stimulator was ignited, the S was asked to watch his after-images in the flickering field on the wall. He was also told to look for lines possibly appearing between the after-images. At the outset, the phenomenon was demonstrated to him under an extremely favorable condition (two long 15 cm flashes separated by a rather small, 1 cm gap) in which fusion was known to occur.

He was subjected to a series of stimulations with two 2 cm flashes. These flashes were successively separated by distances of 1, 2, 4, 8, 16, and 32 cm. This procedure also was performed with a reversed sequence of gap sizes. A similar series was presented with 1 cm flashes.

In the second part of the experiment, the helicoidal flash stimulator was substituted for the linear flash stimulator. Other conditions were unchanged. The S

was instructed to fixate monocularly at fixed points on the board while different patterns of stimuli were presented.

An interval of approximately 5 min. was maintained between observations. Room lights were turned on during this time.

Results

The actual description of the fusion phenomenon by the observers varied slightly. Some described it as a white, others as a blue, luminous line. The primary repeatable observation was that when the actual after-images started to fade, a single continuous straight line bridged the gap between previously separated after-images. It is important to note that the after-images themselves did not move and that fusion was the occurrence of a line bridging the gap between them (Figs. 2 and 3).

The first phase of the experiment with the linear flash-stimulator demonstrated that there was a range of flash sizes and gaps in which fusion occurred and a range in which fusion did not occur. Generally speaking, the limit for fusion was reached by decreasing the size of the flash and increasing the size of the gap. The point where the S stopped seeing fusion when the size of the gap was increased after starting from definite perception often coincided with the point where the S began seeing fusion when the gap was decreased after starting from no perception of fusion.

With the second helicoidal flash-stimulator, results varied. With the two holes uncovered, most Ss saw fusion between the two after-images. With three, a triangular configuration was observed. With four, however, the responses varied from S to S and with the direction of gaze. By fixating at the center of the

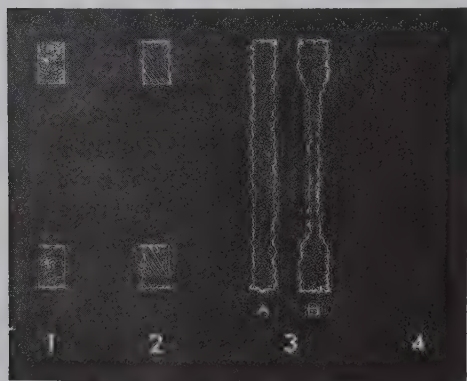


Fig. 2. After-image and fusion sequence produced by linear stimulator seen on a flickering background. (1) After-images immediately after flash. (2) After-images starting to fade. (3) After-image fusion: (A) Width equal to original after-image (B) Narrower than original after-image. (4) Disappearance.

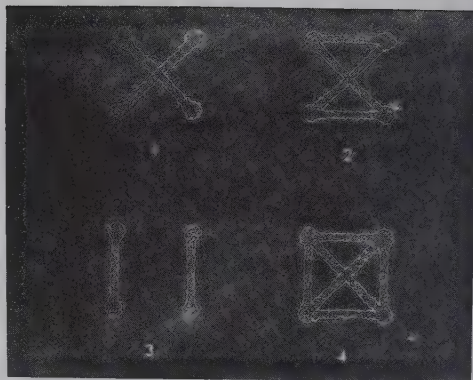


Fig. 3. Different patterns of fusion produced by four spots seen on a flickering background with different points of fixation.

square many Ss reported seeing fusion diagonally connecting the after-images, thus forming an X configuration. While fixating on the side of the square many parallel lines were reported frequently. At least one fusion line consistently crossed the fixation point.

Discussion

As in all subjective phenomena the concept of learning, conditioning, and suggestion had to be considered. Learning did play some role because it was initially necessary to demonstrate fusion under very favorable circumstances.

However, conditioning and suggestion were ruled out as major factors because the Ss had substantially identical transition points between fusion and no fusion, whether approached by increasing or decreasing the gap-size.

Some Ss were confused between lines normally seen crossing a flickering field and the fusion image. This was avoided by reminding them that these lines cross the whole field, while fusion extends only between two after-images.

While these experiments were conducted to explore the after-image fusion phenomenon, their results cast some doubt on a purely retinal mechanism of after-images.

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Note

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Gustatory cross adaptation between salts

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Adaptation of the tongue to any of four different salts tested lowered the estimated magnitude of some other salts, contrary to previous reports. A separate mechanism is not required to code the taste of each salt.

No evidence has ever been found of cross adaptation between salty tasting substances either psychophysically or electrophysiologically. Hahn (1949) compared 24 different salts for cross adaptation in humans in an extensive psychophysical study and found that "the adaptation to any given concentration of salt is always limited in a truly astounding manner to the contained (adapting) salt" (p. 219). A similar phenomenon was found by Beidler (1962) where adaptation to 0.1M CaCl_2 did not influence the response of the rat chorda tympani to 0.1M NaCl, even though both substances are known to affect the same taste cells. These results are of wide importance in taste theory, because they mean that at least 24 different receptor sites or mechanisms are required for salt sensitivity alone; and amazing degree of specificity. This is even more surprising since cross adaptation can occur between stimuli of the different basic taste qualities (Dallenbach & Dallenbach, 1943) particularly between sour and sweet.

In the course of another study, the chance observation was made that adaptation to KCl did in fact alter the taste of NaCl (McBurney, 1965). The present study was designed to further demonstrate the effect and test its generality.

Preliminary Study

Since adaptation has its greatest effect on solutions which are close in intensity to the adapting solution (McBurney, in press), it was necessary in a preliminary study to choose concentrations of each salt which would give the same subjective magnitude. Ss judged the intensity of eight salts by the method of magnitude estimation with no modulus under HOH adaptation. From the intensity function for each salt a value was chosen to be equal to 0.1M NaCl. We found for our two anions (Cl^- and Br^-) that the anion made no contribution to intensity. For each cation the values found for the chloride and bromide seemed to be random samples from the same population. This is also true for electrical recording data (Beidler, 1953). For this reason we pooled the data of the anions and made a single estimate for each cation. These values are given in Table 1.

Method

Human Ss sat with the tongue extended between the lips so that a flow system delivered the solutions to the entire exposed dorsal tongue surface, eliminating the influence of saliva. All solutions were

Table 1

Solutions of Equal Subjective Intensity

NaCl, NaBr	0.1M
KCl, KBr	0.11M
NH_4Cl , NH_4Br	0.051M
CaCl_2 , CaBr_2	0.026M

maintained at 34° C in a water bath and were delivered through the same tube.

All solutions were made in distilled HOH. Each of four groups of Ss judged all eight stimuli (plus eight weaker and 16 stronger stimuli to avoid having all of the stimuli of the same intensity) once under adaptation to one of the chlorides and also after HOH. Adaptation order was counterbalanced and order of stimuli was random and different for each S.

Results

The geometric means of the magnitude estimates were computed for the eight matched solutions. The data are shown in Fig. 1. The circles give the subjective magnitude after HOH adaptation and the triangles after NaCl adaptation. The line connecting the points shows the amount of change. The horizontal lines indicate ± 1 standard error of the mean difference (matched samples).

Discussion

In each group the adapting solution is also used as a test stimulus. The change in this stimulus (e.g. NaCl in Fig. 1) represents ordinary adaptation not cross adaptation. Since the taste of salts adapts completely these changes may be taken as a standard in judging the completeness of adaptation. It is apparent that in most cases the effect is quite small (only 15 out of 28 of the individual cross-adaptation effects are significant at the .05 level). However, of 28 pairs, 26 are positive and none negative (not counting the four cases of ordinary adaptation). It appears that we have strong evidence for a weak effect.

In each group, however, the bromide which has the same cation as the adapting solution (e.g. NaBr in the NaCl group) adapted completely. In fact the bromides on the whole behave as do the comparable chlorides. Whether this would be true for other anions, we cannot say.

We see no satisfactory way of accounting for Hahn's failure to obtain cross adaptation. Although most of his adapting solutions were weaker than ours, he did use some as strong as 3M. The most likely reason for the absence of cross adaptation in his study is the use

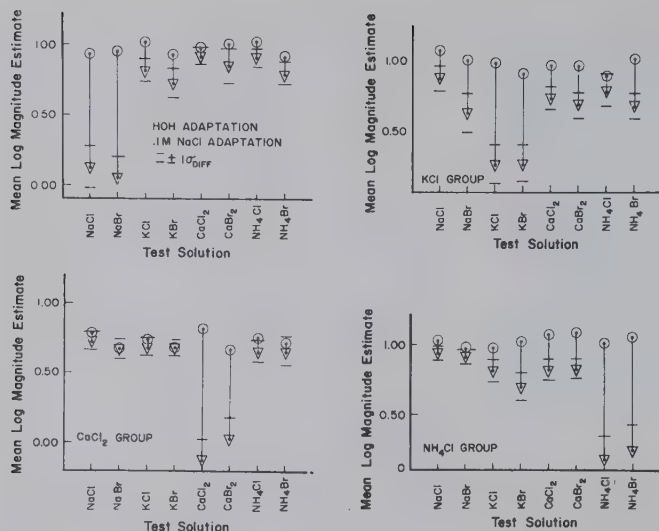


Fig. 1. Estimated magnitude of salt solutions after HOH or salt adaptation.

of thresholds to measure sensory effect. It is conceivable that the detection threshold is not changed by cross adaptation, but only the intensity of supra-threshold solutions. However there are several puzzling aspects of his results. His NaCl thresholds were extremely low; $7 \times 10^{-7}M$ after HOH adaptation compared to a median HOH adapted threshold 1.4×10^{-4} found by McBurney & Pfaffmann (1963). Also, his 0.01M adapted threshold of $3.6 \times 10^{-2}M$ is below the adapting concentration. According to Bartoshuk, McBurney, & Pfaffmann (1964) this would be in the sour-bitter subadapting range so that the quality of salty could not have been perceptible. Evidently Hahn is restricting his definition of salts here to include only those salts that have the typical salty taste. For example, $BeCl_2$ which is sweet cross-adapted with $BeBr_2$ and $BeSO_4$. Also, among salts with a bitter taste, $MgCl_2$ affected NH_4I and $CuCl_2$, for example. It would seem unlikely that sweet and bitter qualities would show cross adaptation and not salty within such a chemically well defined group as salts.

There is not necessarily any discrepancy between these results and those of Beidler. It is obvious that physiological evidence could be found if we knew the correct parameter to attend to. Also, in our experiment $CaCl_2$, which he used as the adapting solution, give very weak cross adaptation.

We hoped that there would be enough differences in amount of cross adaptation between different stimuli to be able to get an idea of the number of sites or mechanisms responsible for salt taste coding from the way in which the pairs grouped themselves, but the effect is too small and similar in most cases. It appears now that the overall intensity of taste may not be the ap-

propriate dependent variable. Further pilot results indicate that the salty taste of each salt is affected more than the overall intensity. Measuring the changes in saltiness should give us a more sensitive and useful measure of cross adaptation. We can state confidently, however, that the number of sites responsible for the coding of the salt taste is less than the number of salts.

Cross adaptation has been used fruitfully in the study of coding mechanisms in other senses. Now that the phenomenon has been demonstrated for salts, we feel that cross adaptation may be of considerable use in the study of gustatory coding.

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The effect of familiarization instructions on associative latency and learning

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This experiment investigates the effects of using different familiarization instructions (Spell or Pronounce) on associative latency and learning. Significant effects (reduction in associative latency and the number of errors to criterion) were obtained only with instructions to pronounce. The implications of this phenomenon are discussed in terms of the effect of familiarization on meaningfulness. The reasons for discarding present, widely-used definitions of meaningfulness are cited.

Recent evidence supports the conclusion that familiarization reduces the latency of Ss' responses to CVC trigrams (Gillooly, 1965) in spite of the earlier data (Riley & Phillips, 1959). Further, it was suggested that it is the familiarization instructions given Ss (Pronounce or Spell) that may be the determinant of the effect. However, the reported experiments (1965) were not designed to test such an hypothesis with the result that there was some confounding of variables—response mode was not the only part of the experimental task that was allowed to vary.

This study seeks to determine (1) if the reduction in associative latency (AL) can be replicated with different Ss and materials, (2) if the familiarization instructions (specifically, mode of response) are the determinant of the effect, and (3) if the reduction in AL is associated with facilitation in a learning task.

Based on the results of the previous studies, it is hypothesized that with respect to AL: (abbreviated terms explained in *Procedures*, and > means "is significantly faster than") H_1 : PRF > PIF, H_2 : SRF > SIF, therefore, H_3 : PRF > SRF. With respect to the learning data, it is hypothesized that there will be facilitation wherever AL is reduced in addition to whatever other facilitation is observed. It should be noted that these hypotheses call for the use of one-tailed tests of significance.

Method

Experimental Design: The design is a 2 by 2 factorial with two sets of instructions (Spell/Pronounce) and two kinds of familiarization (Relevant/Irrelevant). The dependent variables are associative latency and, in the learning task, the number of errors to criterion.

Subjects: Forty-four male undergraduate students who were enrolled in an introductory psychology course were randomly assigned to the four conditions. The use of anova was planned, however, circumstances prevented its use.

Materials and Apparatus: Two lists of 12 CVC trigrams were constructed from the lists in Hilgard (1951). List 1 was column 6 (22.7 average association value according to Glaze, 1928) in Hilgard's Table 7 (p. 540) and list 2 was composed of orthographically different items (no item in list 1 and 2 shared any two letters in common) of low association value from the same table. Associative latencies were measured with a Standard electric timer calibrated in .01 sec. and activated by telegraph key. The trigram lists were pre-

sented in the serial anticipation task by a Gerbrands memory drum.

Procedure: The experiment consisted of three parts—familiarization (on both list 1 and 2), immediately followed by an association test (on list 1 stimuli only), which, in turn, was immediately followed by a serial anticipation task (on list 1 only). The only parts of the procedure which varied were the familiarization instructions and the materials. Familiarization on list 1 is "Relevant Familiarization" (RF) and familiarization on list 2 is "Irrelevant Familiarization" (IF).

Familiarization: In individual sessions, Ss were given a pack of 84 3 in. x 5 in. cards on which were typed (one to a card in upper case letters) either the stimuli of list 1 (for the RF condition) or those of list 2 (the IF condition). Each stimulus was presented 7 times. The packs were shuffled after each S's use. In addition, Ss were given a 7 page booklet containing 84 lines (12 to a page) in which to write the trigrams. Ss were instructed either to (a) *spell* each trigram to himself three times while writing it (the Spell condition) or to (b) *pronounce* each trigram to himself three times while writing it (the Pronounce condition). Thus, in combination with the two lists, there are four familiarization conditions: Pronounce Relevant Familiarization (PRF), Pronounce Irrelevant Familiarization (PIF), Spell Relevant Familiarization (SRF), and Spell Irrelevant Familiarization (SIF).

Association Test: In individual sessions which immediately followed the familiarization procedure, Ss were given an association test. The instructions (same for all groups) stressed that Ss should respond as soon as possible after seeing the trigrams. The stimuli (of list 1) were typed in upper case letters on 3 in. x 5 in. cards. Timings were taken to the nearest .01 sec. from the exposure of a stimulus trigram to the onset of S's response. The stimuli were shuffled after each use. Five practice stimuli were used to acquaint Ss with the procedure.

Learning Task: In individual sessions immediately following the association test, Ss were required to learn (by serial anticipation) the 12 stimuli in list 1. The instructions required Ss to respond by spelling the trigrams. The list was presented by a Gerbrands memory drum set as follows: 3 sec. exposure per item, zero inter-item interval, and 6 sec. intertrial interval. The criterion of mastery was two successive perfect recitations. The dependent variable was the total number of errors to criterion.

Results

Associative Latency: The associative latencies of each S's 12 responses (to the stimuli of list 1) were summed. These data were then subjected to median tests. All p values represent one-tailed tests.

H_1 : A median test of the responses of the group ($N=22$) receiving pronouncing instructions produced a $\chi^2=2.93$ which for $df=1$, $p < .05$ and it is concluded that the PRF group responded faster than the PIF group. The medians are 19.47 sec. and 31.89 sec. for the PRF and PIF groups respectively. Hypothesis H_1 is, therefore, confirmed. Familiarization with instructions to pronounce the materials has decreased these Ss' associative latency.

H_2 : A median test of the responses of the group ($N=22$) receiving spelling instructions produced a $\chi^2=.73$ which for $df=1$, $.25 > p > .15$ and it is concluded that the medians of these two groups (SRF and SIF) are

equal. The SRF median is 24.75 sec. and the SIF median is 30.21 sec. Hypothesis H_2 is also confirmed. Instructions to spell the materials do not produce the same effect as instructions to pronounce.

H_3 : The directionality of the difference between the PRF and SRF groups is such that the PRF group was faster (PRF median=19.47 sec. vs 24.75 sec. for the SRF group). However, a median test showed that the difference is not significant: $X^2=.73$ which for $df=1$, $.25 > p > .15$. Hypothesis H_3 is not confirmed.

The only other comparison which produced significance was that of the RF and IF groups: $X^2=3.27$ which for $df=1$, $p < .05$. The RF group, with a median of 23.16 sec., was the faster (IF median=30.58 seconds).

Learning: A median test of the learning data disclosed that the PRF group attained the proficiency criterion with significantly fewer errors than the PIF group: $X^2=6.60$ which for $df=1$, $p < .01$. The median for the PRF group is 78 errors and for the PIF group is 132 errors.

There was no difference between the SRF and the SIF groups on this learning task ($X^2=0$). As before, the difference between the PRF and SRF groups is not significant ($X^2=.73$ which for $df=1$, $.25 > p > .15$) but in favor of the PRF group. The respective medians are 78 errors (PRF) and 112 errors (SRF).

As was found with the latency data, there was an overall RF group superiority: $X^2=3.27$ which for $df=1$, $p < .05$. The median RF performance was 84 errors and the median IF score was 134 errors.

In general, significant differences in the learning task are found where there are significant differences in AL (PRF > PIF and RF > IF).

Discussion

It is now established that a relatively small amount of familiarization (f) can decrease the latency of Ss' associations to CVC trigrams. This effect, furthermore, is neither list nor subject specific. One determinant of the effect (there may be others) is the f instructions given Ss. A significant decrease in AL has been found so far only with instructions to pronounce the materials.

It is also established that a relatively small amount of f with instructions to pronounce the materials facilitates Ss' learning a list of CVC trigrams whereas the same amount of f with instructions to spell the materials did not produce facilitation. Presumably, the SRF group was not superior to the SIF controls on the learning task either because of the small number of trials or because the learning task was not sufficiently difficult to allow whatever superiority that may exist to become evident (q.v. Riley & Phillips).

It has been known for some time that AL is negatively correlated with ease of learning (Johnson, 1964) but the above data seem to extend our knowledge of the role played by AL by suggesting that the AL of verbal materials is functionally related to the ease with which they are learned.

With respect to the effect of f on meaningfulness (mf), it has been stated (Gillooly, 1965) that, "... it is (now) more difficult to maintain that mf and familiarity are independent concepts (Noble, 1963) ... If the latency of the first associate to CVC trigrams is significantly reduced by f training, presumably associative frequency is increased (by increasing the probability that an associate will be reported in a constant amount of time and/or by leaving Ss more of that constant

amount of time in which to report additional associations)." Since that time, however, Schulz & Thysell (1965) have reported findings which support and extend those of Riley and Phillips by showing that with dissyllables and several degrees of f , associative productivity (AP) remains unaffected (in 30 sec), despite the fact that their instructions required Ss to pronounce the materials to themselves. These results require that speculation about AP cease. Although f decreases AL, AP remains unaltered. Schulz and Thysell conclude "The results of the present study, when considered in conjunction with those obtained previously by Riley & Phillips (1959), would seem to justify a firm conclusion that familiarization does not affect mf . Furthermore this conclusion now has considerable generality ..."

However, the general problem of deciding whether or not f affects mf can only be resolved by choosing among the several definitions of mf . If by mf one means the number of associations produced in a fixed amount of time (Noble's m used by Schulz and Thysell), then he is correct in stating that mf is unaffected by f . However, if one defines the mf of stimuli as being related to the probability that an association will be reported in a fixed amount of time (the familiar Association Value invented by Glaze, 1928, and used by Archer, 1960, among others), then reducing AL would seem to increase this index of mf .

If one wishes to be most direct by asserting that the mf of stimuli is inversely related to the time required to respond with an association (the $\bar{M}$ scale is based on this definition; Gillooly, 1964), then the above reported results demonstrate that f does increase the mf of CVC trigrams.

In choosing among the several definitions of mf , the following considerations seem important: (1) When science can rid itself of a concept by choosing one instead of another definition, that concept is superfluous. Choosing an associative latency-related definition of mf is the parsimonious thing to do. (2) It seems desirable to use as an index of mf one which is sensitive to the maximum number of influences which affect the ease with which verbal material is learned. Noble's m , by being insensitive to the effects of f , resulted in the mystique of familiarity. Defining mf in terms of AL eliminates this problem. Familiarization is seen as a technique for altering the mf of stimuli—not as an independent dimension of verbal material. (3) Regarding mf as being dependent upon f procedures is credible. How else did verbal stimuli acquire whatever mf they possess if not through f procedures (which more often than not involved use of pronunciation) or generalization from familiarized stimuli?

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Children's probability learning as a function of the cross-sex effect¹

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To assess the effects of the sex of E and S on the performance of S in a complex task employing social reinforcement, 6-yr.-old boys and girls were presented a probability learning task in which the sex of the reinforcing agent was varied. The general results indicated that when E was a male, girls made more correct responses than boys, while boys made more correct responses than girls, when E was a female.

In a recent review of the literature on social reinforcement with children, Stevenson (1965) has pointed out that one of the most consistent findings in this research has been the effects of the interaction between sex of E and S on S's performance. In general, the results concerning this interaction have shown that male Es are more effective sources of social reinforcement for female Ss than for male Ss, while female Es are more effective for male Ss than for female Ss.

Although a number of studies have demonstrated the cross-sex effect with children ranging in age from 3 to 8 yr. (e.g., Gewirtz & Baer, 1958; Stevenson, 1961; Stevenson & Knight, 1962), only simple operant tasks, having no solution or goal, have been employed. The purpose of the present study was to investigate the generality of the cross-sex effect in more complex tasks. Since probability learning tasks have been viewed as problem-solving tasks, which become increasingly difficult with increasing age (Weir, 1964), the present study employed such a task with the E as an active participant, taking turns with S in a hide-and-seek game.

Method

The Ss were 32 boys and 32 girls selected from children attending first grade classes in a Nashville elementary school. The Ss were from middle-class homes, and their mean CA was 6 yr. 4 mos. A male and female graduate student served as Es, and an equal number of boys and girls was assigned randomly to each E.

The apparatus was a light blue, rectangular game table, which has been described in detail elsewhere (Stevenson & Odom, 1964). A window shade ran lengthwise over the midline of the table and was lowered at the end of each trial to conceal the activity of E and S. Three boxes were mounted on both long sides of the table top. The rear of each box was open and flush with the table's edge. The top of each box was hinged and could be opened to reveal the inside of the box. The E and S each began the game with 10 plastic trinkets. The E had access to additional trinkets in the event that his supply was depleted.

The E escorted S to the experimental room and introduced him to a second adult (R), who recorded the responses of S and prompted S in the procedure of the game. (The R was always the same sex as E.) After taking a chair across the table from S, E said that they would take turns hiding and seeking trinkets and that at the end of the game the person with the most trinkets would be the winner. The E then began the game by pulling the shade down, hiding a trinket, raising the shade, and telling S to open the lid of the box he thought the trinket was in. Following S's choice, E said that it was S's turn to hide a trinket. If S found one of E's trinkets, E said, "Good, you won," and when E found one of S's trinkets, E said, "You lost." Reinforcing statements were not offered by E when trinkets were not found. This procedure was continued until each participant had 48 hiding and 48 seeking trials. When the task was completed, S was allowed to keep the trinket of his choice.

The E hid trinkets in only one of his three boxes and S was randomly reinforced for 66% of his responses to that box. The S was never reinforced for choosing either of the other boxes. The to-be-reinforced box was varied at random for different Ss with each of the three boxes being correct for an approximately equal number of Ss. The reinforcement schedule was constructed so that the sequence of reinforcement would not be the same for all Ss and so that no more than four consecutive correct responses would be reinforced. The E's seeking responses were determined by a pre-arranged random schedule, with the restriction that each of S's boxes be chosen with equal frequency.

Results

A 2 (Sex of E) by 2 (Sex of S) by 8 (Blocks of Trials) analysis of variance was performed on the number of correct responses, i.e., all responses made to the reinforced box. The only significant main effect was Trials ($F=15.88$, $df=7/420$, $p<.001$), reflecting an increase in the number of correct responses from the first to the last block of six trials for the combined sex of E-sex of S groups.

The significant Sex of E by Sex of S interaction ($F=5.70$, $df=1/60$, $p<.02$) was due to the fact that boys made more correct responses ($M=27.50$) than girls ($M=20.75$) when E was a female, and girls made more correct responses ($M=24.82$) than boys ($M=21.38$) when E was a male. The Sex of E by Sex of S by Trials interaction ($F=2.08$, $df=7/420$, $p<.044$) indicated that the increase in number of correct responses from the first to the last block of trials differed for the groups.

When E was a female, the mean increase in correct responses from the first to the last block of trials was 1.50 for boys and .75 for girls, but when E was a male, the mean increase was 2.12 for girls and 1.00 for boys. None of the other interactions was significant.

Discussion

The results of the present study demonstrate that young children's performance in certain kinds of complex learning tasks can be affected by sex of E and sex of S variables. Since the E's primary role in most studies of probability learning in children is that of providing instructions, the E as an active participant and/or a source of social reinforcement may be essential in determining the cross-sex effect in this kind of task. Nevertheless, these findings emphasize the potential importance of controlling for such variables in research that involves complex as well as simple learning. Control of such variables is not only important regarding research with children but also research with adults, since a recent study using adults as Ss has demonstrated the cross-sex effect (Stevenson & Allen, 1964).

Aside from methodological considerations, the cross-sex effect is of theoretical interest, and explanations for the phenomenon have been derived from Freudian Oedipal theory by Gewirtz & Baer (1958) and from social learning theory by Stevenson (1961, 1965). Both interpretations focus on the reinforcing value that the adult

has for the child. It seems likely that the cross-sex effect found in the present study was a result of S's being more strongly reinforced for choosing the correct box when E was of the opposite sex than when E was of the same sex. Further research is needed in order to assess the characteristics of such reinforcement.

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Note

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Intermittent punishment of responding maintained by variable ratio reinforcement^{1, 2}

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Variable ratio reinforced behavior was observed in five female college students in daily sessions in which no punishment, continuous punishment, and intermittent (VI) punishment were programmed. In three of the five Ss, punishment shock intensities strong enough to suppress all responding under continuous punishment had no effect when VI punishment was programmed at mean intervals ranging from 15.0 sec. to .8 sec. Only one S showed partial suppression, while all others showed either no suppression or complete suppression under VI punishment. The all or none suppression was related to the fact that partial suppression has virtually no effect in reducing shock frequency on the VI punishment schedule, although such suppression may result in substantial loss of reinforcement on the VR schedule.

The results of previous work on intermittent punishment of concurrently reinforced behavior have shown that when moderate to severe punishment is employed, stable response rates are established under intermittent punishment which fall somewhere between unpunished rates and the suppressed rates established by continuous punishment (Azrin, Holz, & Hake, 1963; Zimmerman & Baydan, 1963). However, all of the previous work on intermittent punishment has employed either continuous or variable interval (VI) reinforcement schedules. The present investigation was undertaken to examine the effects of intermittent punishment on human behavior maintained by variable ratio (VR) reinforcement, where any tendency toward suppression would be expected to lead to a drastic reduction in reinforcement.

Method

Five female college students were hired to serve for approximately 15 50 min. sessions. Ss were isolated in a small room containing a table and chair. On the table were mounted a push button (Grason-Stadler E8670A), and a panel which contained two stimulus lamps and an impulse counter. Within sessions, stimuli were programmed on a four-component multiple schedule. Throughout all of the 25 2 min. components, push button responding was reinforced on a VR 75 schedule, the reinforcing stimulus consisting of a counter tally which represented one cent. Components 1 and 3 of the multiple schedule consisted of VR 75/No Punishment, with neither lamp illuminated; component 2 consisted of concurrent VR 75/Continuous Punishment, with the left corner lamp illuminated; and component 4 consisted of concurrent VR 75/VI Punishment, with the right corner lamp illuminated.

Punishment intensity was established on the first two punishment days by gradually increasing shock intensity

in the continuous punishment component until responding was eliminated in that component but not substantially affected during the intermittent punishment component, which was always programmed in the initial sessions at 15 sec. VI. Pilot work had revealed that no suppressive effect occurred at 15 sec. VI punishment. The shock stimulus was a 60 cps, 40 msec. pulse delivered on the index finger of the right hand. Ss were instructed to respond with the right hand.

After shock intensity had been established for each S, two sessions were programmed at each of a number of increasing shock frequencies, i.e., the mean interval of the VI punishment decreased in component 4. Ss, therefore, started with two days at 15 sec. VI in the intermittent shock component, and then received two days at successively higher frequencies until either complete suppression occurred in the VI punishment component, or continuous punishment was scheduled during both punishment components.

Results

The major results are summarized in Fig. 1. Points plotted are relative response rates in the continuous and intermittent punishment components. Relative rates are median responses per sec. during the 6 VI (filled circles) or 6 continuous (open circles) punishment components divided by the median responses per sec. during the 13 no-punishment components of the same session. Absolute response rates during the no-punishment components averaged about 4.5 responses per sec. Data are from the second of two days at each interval of the VI punishment schedule.

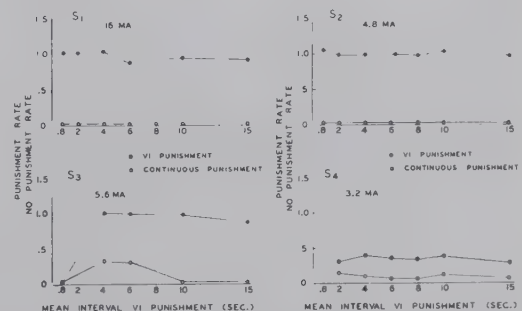


Fig. 1. Ratios of punished to unpunished responding during intermittent and continuous punishment. Ratios are plotted as a function of the VI punishment schedule programmed in component 4 of Mult (VR 75; Con VR75/Continuous Punishment; VR 75; Con VR75/VI Punishment).

The major finding is that with the exception of S_4 , responding of all Ss under VI punishment occurred either at the unpunished rate or not at all. Ss 1 and 2 showed no effect of VI punishment at any mean interval, including .8 sec. Therefore, continuous punishment was programmed during both punishment components for those two Ss, as a result of which all responding dropped out of component 4. At no time did responding in the no-punishment components decrease from levels reached in previous sessions. In fact, absolute rates of responding during the no-punishment components tended to increase over successive sessions for all Ss. S_3 showed no effect of VI punishment until the .8 sec. interval was programmed, after which suppression was complete in the VI punishment component. S_4 varied from other Ss in two ways. First, the shock intensity of 3.2 ma finally used did not completely suppress S_4 's responding during the continuous punishment component, while, second, at that intensity intermittent shock punishment reduced the rate to about 1/3 of the unpunished rate.

Data from S_5 are presented in Fig. 2. The points plotted are again derived from rates during continuous and intermittent punishment divided by the unpunished rate in the same session. They are plotted over sessions, however, since S_5 was exposed only to VI 15 sec. punishment during component 4. In attempting to establish a shock intensity to be used during later sessions, S_5 was moved up to 12.0 ma on the second punishment day, at which point responding was completely suppressed during continuous punishment but was unaffected during 15 sec. VI punishment. In the next three sessions, however, S_5 failed to respond during both punishment components, in spite of the fact that

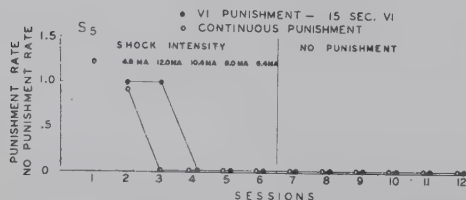


Fig. 2. Ratios of punished to unpunished responding (sessions 2 - 6) for S_5 . Also, ratios of responding in former punishment periods with punishment no longer programmed (sessions 7 - 12).

shock intensity was reduced over those three days from 12.0 to 6.4 ma. After day 6, the shock generator was turned off, but S_5 failed to respond in the former punishment components over the next six sessions of punishment extinction. VR 75 reinforcement was programmed in all components of sessions 7 - 12. Like Ss 1, 2 and 3, S_5 also showed the all or none pattern of responding under intermittent punishment.

Discussion

It would appear that VI punishment is far less effective than continuous punishment in suppressing responding reinforced on a VR schedule. The tendency for responding on the VR schedule to occur at a very high rate or not at all is very similar to results obtained by Azrin (1959) in a study of punishment effects on behavior maintained by fixed ratio (FR) reinforcement. Azrin found that continuous punishment produced longer post-reinforcement pauses but did not affect running rate once the animal started to respond. A plausible hypothesis for the lack of partial suppression in most Ss under VR reinforcement is that unlike the case of interval schedules of reinforcement, where substantial suppression results in relatively little loss of reinforcement, the proportion of reinforcement loss under the VR schedule is directly a function of amount of suppression. In addition, under VI punishment of VR-maintained responding a substantial reduction in rate, although it results in significant reinforcement loss, does not greatly reduce the number of shocks received. Therefore, differential reinforcement for high rates is likely to be the overriding factor in determining rate when responding maintained by VR reinforcement is punished with mild or moderate shock intensities on a VI schedule.

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Notes

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2. The help of Samuel Katchigan and John Uhlarik, who collected the data for this study, is gratefully acknowledged.

Retrieval of long-term memory: "Tip-of-the-tongue" phenomenon¹

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Ss were able to predict better than chance which common-knowledge question that they had missed on a recall test they would subsequently answer correctly on a multiple-choice test. Providing the initial letter of the correct answer significantly facilitated recall as compared to provision of an incorrect first letter or no letter clue.

We are often unable to produce the correct response to a question even though we "know" the answer. It is, we say, "on the tip of our tongue." Although this phenomenon has been described extensively (Freud, 1955; James, 1950), few controlled experiments have been done to investigate its properties. In addition to the phenomenon being interesting in itself, it would seem that studying instances in which retrieval of long-term memory breaks down might be a fruitful method of attacking the general problem of retrieval.

This experiment was conducted to study two specific questions concerning the "tip-of-the-tongue" phenomenon: (1) To what extent can the S accurately report that he does know the answer even though he cannot produce it? Hart (1965) has shown that Ss can predict significantly better than chance which items that they cannot recall they will subsequently be able to identify in a recognition test. The current study replicated this finding. (2) To what extent does a specific clue, i.e., the initial letter of the correct answer, facilitate recall of the unavailable response.

Method

Twenty students served as Ss. Each S listened to a tape recording containing 150 simple questions, each of which could be answered with a one-word response. These questions were constructed on the basis of extensive pretesting which indicated that they were likely to produce a high percentage of blocked responses (i.e., the S would be unable to supply the answer but would report that he thought he knew the answer). Examples: Who was Secretary of Agriculture under Eisenhower? What was Buffalo Bill's real name? The questions were read at the rate of three per minute. After each question, S wrote his answer. He was urged to guess if he had any notion of what the correct answer was. He also noted how certain he was that he knew the answer on a four point scale ranging from certain that he knew it to certain that he did not know it.

The list of 150 was read, there was a brief rest period, and then the same list of questions was read again in a different order. For this second reading, each S was provided with an answer sheet on which one-third

of the questions had printed the initial letter of the correct response, one third had an incorrect letter, and one-third had no letter. Three different forms were used so that each question was represented in each group. Ss were informed beforehand that some of the letters were correct and some were not. For this administration Ss merely wrote their answers; there was no confidence rating. As in the first series, Ss were urged to record an answer even if they were not certain of it.

Finally, all Ss were given a written multiple-choice form containing the 150 questions and six possible answers for each. The Ss circled what they thought was the correct response. They were urged to guess if they had a hunch, but not to make completely wild guesses.

Results

To begin with it should be noted that there were a large number of "tip-of-the-tongue" instances produced. These may be defined as items in excess of chance on which S was incorrect on test I, but correct on test III. Of an average of 95.2 incorrect on test I, an average of 46.0 were correct on test III. Since only 16.7 would be expected to be correct due to guessing, there were clearly many true blocked items.

The first question of interest then is the extent to which Ss were able to report accurately whether or not they knew the answer when they were unable to produce it. The relevant data are the number of items in each of the four confidence categories that were missed on test I and identified correctly on test III. The mean proportions correct were .73, .61, .51, and .35 for confidence ratings of "Definitely know it," "Probably know it," "Probably don't know it," and "Definitely don't know it," respectively. An analysis of variance was performed. The linear trend is highly significant ($F=41.59$, $df=1/57$, $p<.001$) as is the overall effect of confidence ($F=16.93$, $df=3/57$, $p<.001$). In other words, even though he could not supply the correct answer without additional help, S was able to judge quite well whether or not he "knew" the answer. It should be pointed out, however, that this judgment, while quite good, was far from perfect. Even when Ss were certain that they knew the answer, they were correct on only 73% of the items; and when they were certain they did not know the answer, they were still correct on 35%, over twice what would be expected by chance.

The second question was whether or not supplying the initial letter of the correct answer would facilitate production of the answer. The data relevant to this

question consist of the number of blocked items (as previously defined) that were right on test II, when the correct letter, incorrect letter or no letter was given. The mean proportions were, respectively: Right clue, .34; Wrong clue, .12; and No clue, .15. The difference between the correct letter items and each of the other conditions is significant ($t=5.45$ and 4.30 respectively); but the difference between the wrong letter and no letter conditions does not approach significance ($t < 1.0$).

Discussion

How does provision of a hint or clue aid in retrieval of a "blocked" response? One plausible view of the retrieval process is that it consists of some kind of an ordered search through a memory store. A block might then consist of a fixated search in a wrong part of the store. Provision of a new cue might restart the search in another locus, thus providing a second chance for a successful scan. However, in this case one would expect any cue, even a wrong one, to be better than none. This is not the case in our data. Another possibility is that the store is organized according to an ordered array of stimulus properties such that provision of a cue allows entry to the array at a point nearer the desired item. For example, if word responses were

stored alphabetically, then provision of the correct initial letter would lead the search to an alphabetic listing containing the answer, while an incorrect initial letter would lead to a blind alley. Another, more traditional, hypothesis is that the additional cue, when correct, simply adds another modicum of association linkage to that provided by the original question, thus raising the response strength of the correct answer, and perhaps driving it over some emission threshold. The last two hypotheses (among others) do not seem separable on the basis of available data.

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Note

1. We thank Robert Gilbert for assistance in running the experiment, and Anthony Doob for help in the data analysis. The research was supported in part by National Science Foundation grant No. G. S. 196.

Free recall of intralist items as a function of serial position, association value and conceptualization

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Eight lists were developed each consisting of four words with high association values and four words with low association values. Words were alternated within the lists on either a high, low, high, low or a low, high, low, high scheme. Some lists had high intralist association value (a common associate for the words in the list) while others did not. The different alternation patterns modified the normal serial position curves. The presence of a common associate did not facilitate recall.

Many studies have shown that meaningful material is learned faster and retained better than less meaningful material (Underwood, 1964). The typical approach to investigation in this area has been to give two or more equated groups of Ss tasks varying in meaningfulness, with some aspect of association value being used as the meaningfulness measure. Validation data on the use of association value as a general index of meaningfulness between tasks have accumulated from various sources (Noble, 1952). Most studies, however, have been primarily concerned with inter-task learning differences rather than intra-task differences.

Recently, Roberts (1965) has shown in a study of semantic satiation, that the serial position curve of eight-item lists was in part a function of the association values of items within each list.¹ The present investigation was designed to vary systematically association value within eight-item lists to further explicate the relationship between association value and recall.

Method

Materials. Eight eight-item lists were derived from the concept formation materials developed by Underwood & Richardson (1956). One list derived from the materials was: rice, flea, atom, closet, pin, minnow, pollen and crumb—with an associated descriptive adjective "small." Seven other eight-item lists were constructed using different descriptive adjective categories. The nouns within a list, however, were more or less associated with the descriptive adjective, and the association values, as published by the above authors, were indicators of this degree of association.

Low association items were defined as nouns with association values less than 53%, whereas the values for the high association items were greater than 58%. In Group 1, words within each of the eight lists were arranged on a L-H-L-H association value basis. In Group 2, the words from each succeeding two serial positions for all eight lists were reversed, so that the

items within each list were alternated on a H-L-H-L association value basis. In Group 3, four of the eight lists were alternated on each of the association value schemes. Also, the words in Group 3, were grouped so that words within each list were not commonly associated with any particular descriptive adjective. Words were individually printed on transparencies and shown by a slide projector.

Procedure. Each group was told that they were to participate in a simple experiment on memory. After this, each S was handed a mimeographed sheet of paper and told it would be used later in recalling certain words. The E then proceeded to read the typical directions which are given in free recall studies. Ss were told that their recall of the lists did not have to be in the same order that was presented.

A 1 min. recall interval was given following each list presentation. The inter-word interval was controlled manually; however, every effort was made to keep this interval as close to 2 sec. as possible. The order of list presentation was held constant for all Ss.

Subjects. In Group 1, thirty introductory psychology students were used. In Groups 2 and 3, 53 and 48 Ss respectively were taken from undergraduate educational psychology classes. All Ss were enrolled at Florida State University.

Results

Figure 1-A presents the serial position curves for the eight-item lists for Groups 1 and 2. Also plotted

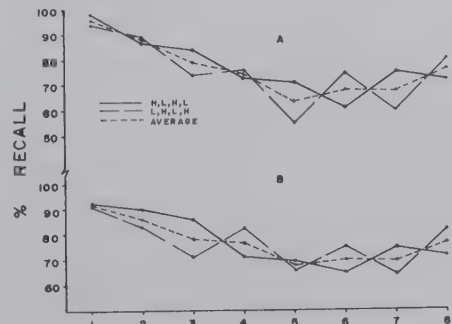


Fig. 1. Serial position curves for lists where association value was varied from position to position.

is the average curve which theoretically represents what the serial position curve would have been if high and low association value items were distributed evenly over each position. In Group 1 it would be expected that positions 1, 3, 5, 7 would be relatively lower than the comparable positions in Group 2. Just the reverse relationship would be predicted for positions 2, 4, 6, 8. This relationship was found at every position. The probability of obtaining eight out of eight correct predictions is less than .001 (binomial expansion; $p = .5$, $n = 8$). In Fig. 1-B, the serial position curves for Group 3 are presented. Again, the same up-down trend is apparent except for position 2 where no reversal was obtained. In this case the probability of being correct on seven of eight predictions is less than .01 ($p = .5$, $n = 8$).

A comparison between the average recall and serial position curves in Groups 1 and 2 (common associate available) with Group 3 (no common associate available) is presented in Fig. 2. It can be seen that the curves are highly similar. Mean recall was 6.16 and 6.13 for Group 3 and Groups 1 and 2 respectively. The difference of .03 was not significant ($t < 1$; 129 df).

Discussion

Although the present study has provided evidence that the amount of recall at any given serial position is a function of association value, two points related to these findings are worth mentioning. First, the way in which Underwood & Richardson (1956) derived associa-

tion values for their concept formation materials—that is, nouns being related to descriptive adjective categories—would lead one to restrict the usefulness of the numerical association values to the appropriate category from which it was derived. However, there seems to be a more general validity involved in these association values. This becomes apparent when looking at Fig. 1-B. These lists were rearranged so that the common associate was not available after the complete presentation of each list. Although the lists were scrambled, when dividing the eight lists into the sublists (L-H-L-H and H-L-H-L), the up-down effect is still readily noticeable. Another point related to the above discussion is that the high and low association value words, as defined in the present investigation, are not related to the Thorndike-Lorge list. By comparing the frequency of occurrence of AA, A, etc. words included in the high and low association value word groups, no relationship was found that might account for recall at any given serial position.

The fact that recall was equal when the associate was or was not available seems difficult to interpret. It would be predicted that Ss would be able to recall more words if some conceptual term were available to facilitate retention. There may be a difference between the concept attainment process and the retention of items within the concept, however. Another point which may be important is the Ss were only given one trial for each list. It seems logical, though, to expect trials to a criterion of perfect recall to be significantly different, favoring, of course, the group in which the common associate is available.

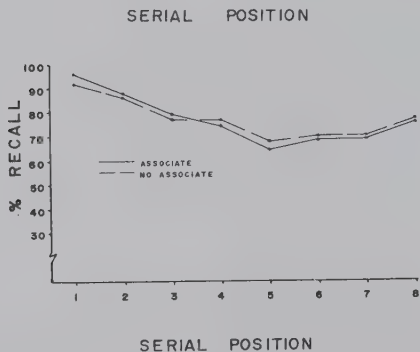


Fig. 2. Serial position curves for lists where a common descriptive associate was or was not available.

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Note

1. A copy of this study may be obtained by writing the Institute of Human Learning at Florida State University.

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Decreased tolerance of hypothalamic hyperphagics to quinine in drinking water¹

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Thirsty hypothalamic hyperphagic rats are less willing than normals to drink water containing quinine. This finding makes tenuous the inference, which has been made by other investigators, that hypothalamic hyperphagics' unwillingness to eat quinine adulterated food implies that their hunger drive is low.

It is well established that animals with bilateral lesions in the ventromedial hypothalamus over-eat and so become obese if they are allowed ad libitum access to food (Hetherington & Ranson, 1942). Since lesions of the lateral hypothalamus cause anorexia which is unalleviated by ventromedial lesions, and since stimulation of the lateral area elicits feeding behavior in satiated animals (Miller, 1960), it has been suggested (Anand & Brobeck, 1951; Brobeck, 1960) that the ventromedial hypothalamic area exerts an inhibitory influence on lateral "feeding centers" in the normal, satiated animal. The hyperphagia resulting from ventromedial lesions, then, presumably reflects the unbridled action of the lateral "feeding centers" and seems to imply tonically voracious hunger.

Miller, Bailey, & Stevenson (1950), however, have demonstrated that hypothalamic hyperphagic rats are less willing than normal rats to do work or to overcome obstacles to obtain food; in particular they will not eat food made bitter by the addition of quinine. Thus, while measures of food consumption indicate that hunger in ventromedially lesioned rats is increased, other measures indicate that it is reduced. More recently, Graff & Stellar (1962) have presented some evidence suggesting that hyperphagia can occur with very little of the finikiness discovered by Miller et al. Their paradox, then, might be fully resolved if it were additionally shown that hyperphagic rats' unwillingness to overcome obstacles on the way to food is a manifestation of some general dysfunction which is not particularly related to hunger at all. It is shown here that hyperphagics, who are unwilling to eat food made somewhat bitter by quinine, are also unwilling to drink quinine-bitter water to relieve thirst.

Method

Successful hypothalamic hyperphagia was induced in 11 female Sprague-Dawley rats averaging 263 gm body weight at the time of operation by placing bilateral electrolytic lesions in the ventromedial hypothalamus; 11 unoperated animals from the same population served as controls.

Number 1840 (Anchor brand, taper point) stainless steel needles insulated except for 1/2 mm at the tip

were lowered stereotaxically to coordinates (deGroot, 1959, system) 5.0 mm anterior to and 1.5 mm dorsal to the inter-aural line at 0.5 mm on either side of the midline to serve as anodes for production of lesions which were effected by passage of a 1.2 ma current for 30 sec. between stereotaxic ear bars and anode.

After at least two weeks of recovery from the operation, the rats' ad lib Purina chow intake and weight gain were measured for a five day period; hyperphagics were selected by the criterion that they should eat at least 5.0 gm per day more than any control rat. Hyperphagics consumed 47.1 gm per day; normals consumed 19.3 gm per day. Hyperphagics gained 8.21 gm per day; normals gained 0.64 gm per day.

It was necessary to equate the groups' food consumption during water intake measurements to avoid artifacts resulting from differential food intake, but the groups were not equated for body weight. Animals had ad lib water but no food from 9:00 a.m. to 7:00 p.m. daily. At 7:00 p.m. water was removed and each rat given 10 gm Purina chow, an amount which would be entirely consumed during several hours even without water. At 10:00 p.m. a test solution either of tap water or quinine hydrochloride in tap water was introduced and left until 9:00 a.m. the following morning, at which time the

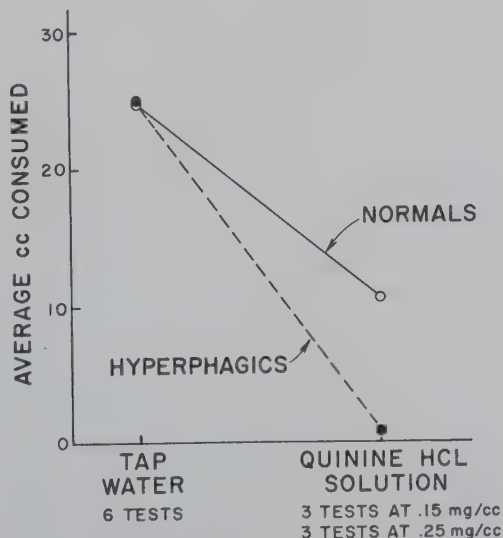


Fig. 1. Tap water and quinine water consumption of normal and hypothalamic hyperphagic rats.

volume which had been consumed was recorded. Plain tap water and quinine water test days were alternated; solutions of 0.15 mg and 0.25 mg of quinine per cc of water gave similar results which were pooled.

Results and Discussion

The results are given as Fig. 1. Thirsty hyperphagics and normals drink the same amount of tap water, but hyperphagics drink very little quinine water compared to normal controls.²

The percent decrement in consumption due to adding quinine to the drinking water was computed for each rat and a *t* test done to compare the groups; *t* = 6.26 with 20 degrees of freedom (*p* < .001).

Thus, hyperphagics will tolerate quinine in neither food nor water.

It is often observed that ventromedial rats are sluggish (Hetherington & Ranson, 1942) and "hyperemotional" (Anand & Brobeck, 1951; Hetherington & Ranson, 1942); these symptoms, as well as lack of tolerance for bad taste, may be non drive-specific dysfunctions which are produced in addition to (but independently of) increased hunger. In any case the present results further emphasize that ventromedially lesioned rats are abnormal in many ways and not only in their regulation of food intake.

Comment on Jacobson et al by David J. Barker

Jacobson et al (1966) report data from an experiment in which RNA from rats rewarded for choosing one or the other side of a two-choice apparatus was injected into naive rats, whose side "preferences" in the apparatus were then measured. Table 1 of their data shows "preferences" of test animals as indexed by their "predominant" choices on 25 test trials, regardless of the strength of "preference." The authors, however, do not make explicit what they mean by a predominant choice. Examination of Table 1 shows that of the 42 test rats, 29 chose the alternative to which their donor rats had been trained (a+d diagonal). Referring now to Table 2, the distribution of scores of the test rats, it is clear that these 29 rats must have come from the upper half of the distribution which includes the scores from 13 to 21. Thus, one would assume that the definition of a "predominant" choice was selecting the alternative to which the donor had been trained 13 or more times out of 25. Under the assumption that the injection of RNA from a donor rat into a recipient rat did not influence the recipient's choices, that its choices were random, the probability of 13 or more choices of the donor-trained alternative out of 25 is quite high (*p* = .50). Thus, while the fact that 29 out of 42 rats showed a "preference" for the side to which their donor had been trained is statistically significant (*p* = .01), it is highly likely that many of these "preferences" were random choices, and not due to the injection of RNA. If the criterion for "predominant" choice had been 14 out of 25 instead of 13 out of 25, the number of rats choosing the alternative to which their

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Notes

1. The work reported here was done at Yale University during the tenure of a National Science Foundation Predoctoral Fellowship. It was supported by Grant M647 from the National Institute of Mental Health, United States Public Health Service. The writer wishes to thank Professor Neal E. Miller for helpful suggestions.
2. The present lack of a between-group difference in tap water consumption should be compared with results reported in Stevenson et al (1950).

donor had been trained would have been 21 out of 42, a result which is not significant (*p* = .50). It would seem that in such an important and controversial research area, a more conservative definition of "predominant" choice should have been adopted, with strength of preference taken into account. This seems especially important in view of the fact that Gross & Carey (1965) twice failed to replicate the Babich et al (1965) study of the transfer of a response by injection of RNA.

The authors conclude from their results that "... specific training given to donor rats was a determinant of the subsequent choices of recipient rats." This strong conclusion does not follow from the results presented. All that a significantly large Chi square implies, in this case, is a lack of independence between "preference of injected rats" and "side to which donor was trained." It does not indicate that one determined the other. A quote from Hays (1963) may be appropriate here: "Given a large enough sample size, the chances are very good that the psychologist can demonstrate the association of any two qualitative attributes via a Chi square test."

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For Reply to David J. Barker see page 334.

Fighting in pigeons relative to available space

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Fighting in pigeons was studied in relation to available space in cages of four sizes. Behavioral measures consisted of frequency of fighting response, response latency, and time of final fighting response. In general, fighting was found to increase with a decrease in available space although the visual properties of the space appeared to be important in determining the frequency of fighting and response latency. Other factors such as age and pre-fighting behavioral patterns also appeared to contribute to the frequency of fighting.

A great deal has been written about territorial fighting in many species of birds (e.g. Tinbergen, 1953, 1954). Fighting in pigeons has received little attention. Territorial fighting in pigeons who maintain permanent nesting sites may differ from that of the seasonal breeders previously studied. Territoriality as used here will refer to an observable division of space that cannot be entered without attack by the occupant.

Fighting in pigeons has been described as a highly stereotyped pattern of behavior by Levi (1957), and by Reynolds et al (1963). Reynolds et al found that this pattern could be conditioned, but once initiated continued independent of the reinforcer.

In addition to observational studies of territorial fighting, a few well controlled studies have been reported in which fighting was related to specific dimensions of available space. Ulrich & Azrin (1962) found that pain elicited fighting in rats occurred on 90% of trials with a 6 in. x 6 in. floor space but on only 2% with a 24 in. x 24 in. floor space. Clark (1962) reported that fighting in mice increased with confinement in a small space. He reasoned that the sudden disruption of customary territoriality resulted in increased excitability and an accompanying increase in aggression. Marler (1956) observed that fighting in Chaffinches increased in probability with smaller distance between birds at a feeding station.

The purpose of the present study was to investigate the relationship between fighting pigeons and available space. It was hypothesized that fighting would increase as available space decreased and that fighting would cease sooner in spaces large enough to permit the establishment of territory.

Subjects

Seven Modenas and one Racing Homer were used as Ss. All were experimentally naive males. The birds had mates and were housed in a common loft. Six had 1964 seamless bands, one had a 1959 band, and one had a 1957 band. They ranged in weight from 391 to 521 gm when the study was begun. All birds were on ad lib food and water.

Apparatus

Fighting was observed in four cages. Cage A was 28 in. wide, 34 in. long, and 29 in. high. Cage B was 24 in. wide, 29 in. long, and 21 in. high. Cage C was 20 in. wide, 24 in. long, and 12 in. high. Cage D was 16 in. wide, 16 in. long, and 9 in. high. Cages A, C, and D were commercial animal cages with a combination of solid panel and grillwork sides. Cage B was made for this study in order to obtain a size midway between A and C. Response time was recorded with a stopwatch.

Procedure

A round robin tournament was used, each bird paired with every other bird. The resulting 28 combinations were paired for two sessions in each of the four cages yielding a total of 224 sessions. No pair of birds was run on consecutive sessions, otherwise order was randomized. Sessions were 5 min. in length. Birds were returned to the home loft after 5 min. whether or not fighting occurred. Pecking and wing slaps were recorded as fighting. A judge recorded the number of fighting responses for each bird after each 5 sec. interval. Preliminary observations on other birds indicated a high degree of inter-judge reliability. Male pigeons are extremely quiet during their incubation period from 10 a.m. to 3 p.m. so no sessions were run during this period.

Results

The data made possible an analysis of the number of fighting responses, response latency, and time of the last fighting response. The total fighting responses for all sessions were 173 in A, 82 in B, 468 in C, and 1473 in D. A high frequency of sessions in which no fighting occurred resulted in a skewed distribution that was not appropriate for a parameter analysis. A Friedman two-way analysis of variance by ranks of the 28 pairs in four cages yielded a X^2_r of 16.6 with $df=3$, and $p < .001$.

A second analysis of the data was made of the frequency of sessions in which fighting occurred for the four cages. The frequencies are as follows: A—fighting in 27 of 56 sessions, B—in 18 of 56, C—42 of 56, and D—50 of 56. A chi-square analysis yielded a X^2 = 46.96 with $df=3$, and $p < .001$.

Response Latency. The median times for the first fighting response (in sessions where fighting occurred) were as follows: A 30 sec., B 45 sec., C 20 sec., and D 15 sec. A chi-square analysis with three time divisions by four cages resulted in a X^2 = 19.33 with $df=6$, and $p < .01$.

Time of Final Fighting Response. The median times for the final fighting response for the four cages were:

A 60 sec., B 67.5 sec., C 150 sec., and D 267.5 sec. A chi-square analysis with three time divisions by four cages yielded a $X^2=7.32$ with $df=6$, and $p<.01$.

Other Factors Related to Fighting. In addition to available space other factors were observed for possible relationships to fighting. They were: size, dominance in the home loft, age, and pre-fight behavior patterns.

We might guess that the size of an animal would contribute to his ability as a fighter, but there is no support for this guess in this data. A rank order correlation between weight and number of fighting responses resulted in an $r_s=-.19$. When dominance was defined in terms of greater frequency of fighting responses for a particular session, a rank order correlation between weight and frequency of session dominance yielded an $r_s=-.39$. The largest animal was observed by a number of independent observers to dominate fighting in the home loft in neutral areas. In this study he ranked sixth in total fighting responses, sixth in frequency of session dominance, and had the highest number of sessions in which he did not fight.

Two of the birds were considerably older than the others. When these birds were paired fighting occurred least often, in only two of eight sessions. They had the lowest total of fighting responses, nine as compared to the high of 217. One of these birds was an opponent in the pair with the highest total. Apparently older birds tend not to fight with each other although they do fight frequently with younger birds.

Coaxing or strutting is one of the most frequent behavior patterns for male pigeons in a home loft. A detailed description of this pattern may be found in Levi (1957). When coaxing occurs in the presence of a receptive female, she initiates billing which is followed by copulation. In new situations or in similar situations with new birds, coaxing often occurs regardless of the sex of the other birds. When the other bird turns out to be a male, the coaxing male usually receives a peck for his performance. In the experimental sessions coaxing often occurred even though the birds had been housed together for months prior to the beginning of the study. In 137 sessions in which coaxing occurred fighting followed in 78. In 87 sessions in which coaxing did not occur fighting occurred only 23 times. A chi-square analysis of this data yielded a $X^2=19.98$ with $df=1$ and $p<.001$. Fighting was considerably more probable when coaxing first appeared.

Discussion

In this study a decrease in available space was accompanied by higher rates of fighting in pigeons as it did in studies with rats, mice, and chaffinches. This generalization was most clearly supported by the data on the final fighting response. In the largest cage territories were established and fighting tended to cease at an earlier time. The bird who was dominated remained quiet in a particular corner of the cage while the dominant bird paced throughout most of the space.

Results based upon number of attacks and response latency did not provide unqualified support for the generalization relating fighting and space. Attacks were least frequent and latencies longest not in the largest cage, but in the next size smaller. This cage (B) differed from the others in that the surrounding areas of the lab were much more visible from the cage. When placed in this cage birds tended to walk around looking outside the cage rather than at each other. It would appear that a meaningful generalization concerning fighting and space should specify the visual properties of the space.

Factors other than the properties of the space appear to effect fighting in a restricted space. There was some evidence that the age of the birds and the patterns of behavior prior to fighting were important. On the other hand, size which was mentioned as important in the fighting of mice by Clark (1962) was not found to be related to fighting in pigeons.

Finally generalizations based upon studies such as the present one may have application only to situations new to the animals since the relative rate of fighting for the birds in this study was quite different from that in the home loft.

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Food deprivation and reactivity to shock

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Thirty-two albino rats, under no deprivation or under severe food deprivation, were given 10 series of 12 different shock intensities, using the method of constant stimuli. Their reactions were classified into several categories. For the vocalization category, thresholds were significantly higher for the deprived group while no differences were obtained on flinch or jump thresholds.

Kendler (1965) has suggested that one effect of an increase in motivation may be to lower stimulus thresholds. However, Griffiths (1962), using single 0, 12, and 24 hr. deprivation periods, found a negative relationship between hunger and reactivity to shock in the albino rat. In this study, vocalization, urination, defecation or "any vigorous movement" was used as an indication of the noxiousness of the shock.

In a study of the effects of shock intensity on the reactions of non-deprived rats, Kimble (1955) has indicated that typical reactions to shock vary with stimulus intensity, with a predominance of flinch responses to low shock intensities, and jump responses to high intensities. Moreover, Harvey & Lintz (1965) have demonstrated that certain subcortical lesions can decrease jump thresholds, without altering flinch thresholds.

Since no direct comparison can be made between the single response category used by Griffiths, and the flinch and jump categories of Kimble, it is obvious that changes in the type of response to shock could occur with increase in hunger, without being appropriately reflected in a threshold for "any vigorous movement." Accordingly, the present experiment attempts to compare

flinch and jump thresholds for rats under zero and severe food deprivation conditions. A further category, vocalization, which was used by Harvey and Lintz, is also included.

Method

The Ss were 32 female Holtzman derived rats, from the colony maintained by the University of Hawaii Psychology Department. They were 90-120 days old at the beginning of the experiment. Sixteen randomly selected Ss were placed on a 23-1/2 hr. deprivation schedule, and weighed every other day for a 10 day period before the experiment. The remaining 16 Ss were given ad lib access to food and water, but were weighed at the same times as the deprived animals.

During testing, each S was placed in a Grason-Stadler operant conditioning chamber, and allowed 3-5 min. to explore. Shocks were presented through an E1064GS shocking source. Twelve stimulus intensities (.05, .10, .20, .30, .40, .50, .60, .80, 1.00, 1.30, 1.60, and 2.00 ma) were used. Stimulus duration was .2 sec., and the average interstimulus interval was 10 sec. Order of presentation was random within each block of trials, with each stimulus intensity being presented once per trial block, for a total of 10 trial blocks. Jumps, flinches, and vocalizations were judged according to the criteria used by Harvey and Lintz. The E who judged these responses did not know the stimulus intensity on any given trial, or the S's experimental condition.

Results

Figure 1 presents the proportion of flinch, and jump, responses of the two groups as a function of stimulus

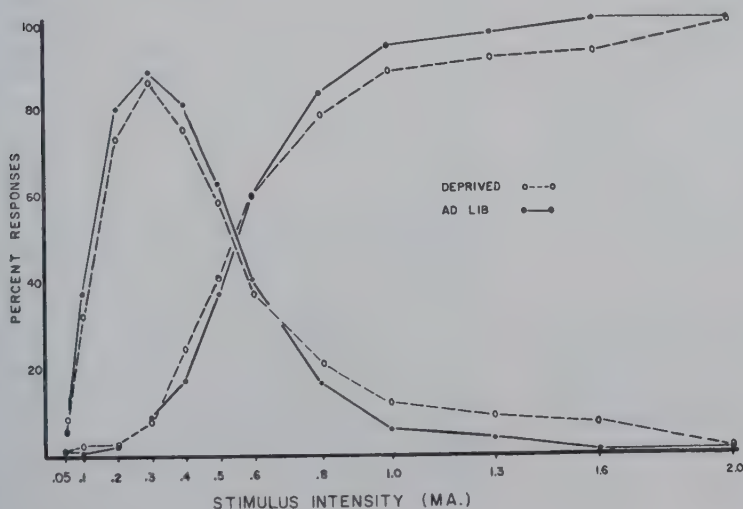


Fig. 1. Proportion of flinch and jump responses at each stimulus intensity, for deprived and nondeprived rats. Flinch response curves peak at left; jump response curves are asymptotic at right.

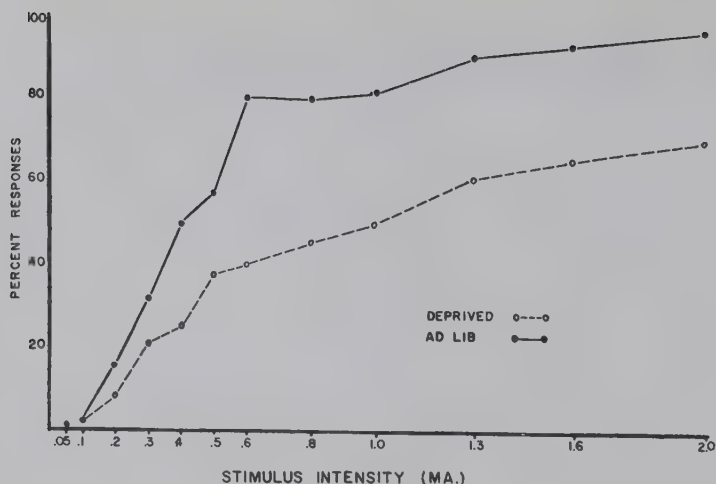


Fig. 2. Proportion of vocalization responses at each stimulus intensity, for deprived and nondeprived rats.

intensity. Visual inspection of these curves indicates no major differences between the deprived and sated groups, although there is some tendency for deprived Ss to give fewer jump and more flinch responses to stimuli of higher intensities. For each S, jump, flinch, and vocalization thresholds were computed by linear interpolation to the intensity at which the appropriate response was emitted on 50% of the trials. For the deprived group, the average flinch threshold was .15 ma, which was not significantly different from the sated group's threshold value of .14 ma ($t = .90$; $p > .05$). The average jump threshold was .54 ma for both groups.

Figure 2 presents the percentage of vocalization at each stimulus intensity. It is evident that, for vocalization, there are large and consistent differences between the groups, with deprived Ss giving fewer vocalization responses at each intensity level. The average vocalization threshold for the deprived group was .88 ma, which was significantly different ($t = 2.89$; $p < .01$) from the average vocalization threshold of .44 ma for the sated group.

Since the deprived Ss ranged from 70–83% of original body weight when tested, a correlation coefficient was obtained to determine if weight variations within this range were related to amount of vocalization. The r for per cent weight loss and total amount of vocalization, was $-.69$, which indicated a significant correlation between these variables ($t = 3.57$; $p < .01$).

Discussion

Despite several differences in procedure, the results of the present study, with respect to sated Ss, are in close agreement with the findings of Kimble (1955) and Harvey & Lintz (1965). The present use of a vocalization category provided an ordering and spacing of flinch, vocalization, and jump thresholds which was virtually identical to those of Harvey and Lintz.

Like the Griffiths (1962) study, the present investigation provides no evidence for the suggestion that deprived Ss are more sensitive to shock. However, except for vocalization, the present study also suggests that they are not less sensitive than sated animals. Moreover, the present vocalization results may provide an explanation of Griffiths' findings of higher thresholds for deprived Ss. Since Griffiths defined the S's response in terms of vocalization and vigorous reactions, his finding that hungry Ss are less reactive to shock may only reflect differences in vocalization, for which the threshold is markedly lower in sated Ss in contrast to deprived Ss.

The obtained correlation of $-.69$ between weight loss and vocalization, despite the restricted weight loss range, indicated that weight loss is a strikingly influential variable in the determination of vocalization to shock. It would appear that this influence is not due to inanition, since inanition would also be expected to influence flinch and jump thresholds. In addition, all deprived Ss seemed healthy and vigorous throughout the experiment. Finally, Moskowitz (1959) found an increase in running wheel activity in the albino rat, with up to 40% weight losses.

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The learning of patterned strings problems by rock squirrels¹

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A sequence of patterned strings problems was presented to four rock squirrels in a scaled down WGTA. All Ss learned a series of parallel patterns; however, only one S was able to learn the entire sequence including crossed and pseudocrossed patterns. The later performance of this S on an intermixed series of crosses and pseudocrosses indicated that it could not perform efficiently on both problems simultaneously.

Patterned strings problems are typically defined by presenting S with various configurations of two or more strings, one of which has a conspicuous reward attached at one end. The S learns to select the string with the attached reward and in so doing must utilize the position of the reward relative to the pattern formed by the strings.

Past investigations of patterned strings learning have been conducted most exclusively with primates including rhesus monkeys (Harlow & Settlage, 1934), chimpanzees (Finch, 1941) and lowland gorillas (Riesen et al, 1953). Some work on string pulling by dogs and cats has been reported (Richardson, 1932; Trueblood & Smith, 1934) but this research was, more often than not, informal and anecdotal and did not conclusively demonstrate discrimination of different string patterns by these carnivores. However, more recently, Michels et al (1961) showed that raccoons can become proficient at solving moderately complex string patterns if a sufficient number of trials are presented.

The study of patterned strings performance in the rock squirrel was undertaken in order to determine the extent to which a member of the rodent order can evidence learning on this task. Among the rodent species, squirrels would appear to be particularly well suited for patterned strings testing because of their highly developed visual and manipulatory abilities.

Method

The Ss were three female (F1, F2, and F3) and one male (M1) adult rock squirrels. All of these Ss had been raised in captivity and had extensive previous experience on discrimination and reversal learning-set problems (King, 1965).

Testing was conducted in a scaled down version of the WGTA. The strings were constructed from 1/8 in. silver beaded chain with swivel hooks at each end. The strings were attached to the front edge of a 14 in. by 9-3/4 in. black sliding tray which was tilted toward the test cage at a 5° angle. The food cup was a 1-1/4 in. diameter cylindrical section of aluminum weighing 52 gm which had a small depression on the top into which bits of raisins were inserted as rewards.

The Ss were initially trained to pull in a single baited string centered on the tray. All Ss learned to perform the chain pulling efficiently within three or four 1/2-hr. test sessions by using both their front paws and their teeth. The Ss were then tested for 25 trials per day on the sequence of patterns which are shown in Table 1. This sequence began with a series of parallel patterns of increasing difficulty (1 through 4) and ended with crossed and pseudocrossed patterns (9 and 10). There was a 1/2 in. gap between the two strings at their closest point in the pseudocross. The two asymmetrical patterns (5 and 8) were placed in mirror image reversals every five trials.

The Ss were tested on each pattern until they attained a criterion of 20 out of 25 correct trials, all within a single test session. If an S failed to meet this criterion within 2500 trials, testing of that S was discontinued. In order to prevent the establishment of strong position habits, whenever an S responded to one side on 10 successive trials, the opposite side was consistently rewarded until a response to that side occurred. If an S learned all 10 patterns, it was then presented with 250 trials of an intermixed series of crosses and pseudocrosses with the sequence of patterns derived from a Gellerman series.

Results

Table 1 depicts the total number of errors committed by each S on each problem that was learned. These data show that the Ss were quite slow in learning the initial parallel pattern (4 in. strings) and that there were marked individual differences, the number of errors to criterion varying from 27 to 1036. The subsequent parallel patterns (Nos. 2, 3, and 4) were learned with more facility than the initial parallel pattern but the transfer was far from complete.

Following introduction of the nonparallel patterns, F2 failed to reach criterion on the slanted pattern (No. 5) while F3 and M4 failed to reach criterion on the diverging (No. 6) and the converging (No. 7)

		PATTERN (Scale: 1 in = 5 in)									
		1	2	3	4	5	6	7	8	9	10
SUBJECTS	F1	27	47	92	15	43	2	86	121	36	736
	F2	1036	10	40	41	x					
	F3	337	12	5	174	138	x				
	M4	128	2	47	4	534	42	x			

x SUBJECT FAILED TO REACH CRITERION WITHIN 2500 TRIALS

Table 1. Errors to criterion for each pattern.

patterns respectively. Only F1 completed the entire series of problems, learning both the crossed and the pseudocrossed patterns. After this S learned the crossed pattern with 36 errors, it committed 736 errors during the learning of the pseudocrossed patterns, a result which suggested negative transfer from the former to the latter pattern.

During the first half of the intermixed series of crosses and pseudocrosses, F1 made 67% correct responses on the pseudocrosses and 47% correct responses on the crosses ($p < .04$ with 2-tailed binomial test). There was no significant difference between performances on the two patterns during the second half of the intermixed series.

Discussion

This experiment has shown that, given sufficient practice, rock squirrels are capable of learning simple patterned string problems. This outcome demonstrates that patterned strings learning is possible in rodents as well as in carnivores and primates. However, even the 4 in. parallel pattern was clearly a formidable problem for the squirrels. Only one of the four squirrels tested was able to complete the entire sequence of the problems and the performance of that squirrel on the intermixed series of crossed and pseudocrossed patterns gave no evidence that it was able to perform above chance level on both patterns simultaneously. In contrast, Michels et al (1961) showed that raccoons, after learning crossed and pseudocrossed patterns separately, were able to perform efficiently on an intermixed series.

The low performance of the squirrel that was tested on the intermixed series suggests that it was not learning

to follow the paths of the chains during the preceding problems but was instead learning a spatial discrimination conditional upon the location of the food cup. Relatively small gaps between the locus of response and the discriminative stimulus typically result in markedly lowered performance in the WGTA (see Stollnitz, 1965). If patterned strings learning by rock squirrels is regarded as a simple discrimination problem, then the slowness of this species to learn simple parallel patterns is consistent with the importance of stimulus-response contiguity in discrimination learning.

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Note

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Strategies and cross-modal transfer in monkeys¹

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Thirteen monkeys were given object-discrimination LS training both tactually and visually. Order of training in the two modalities was varied. Analysis of performance in terms of Levine Hs suggested that Ss transferred systematic modes of response, rather than specific hypotheses, from one modality to another.

There is some evidence that discrimination learning set (DLS) experience in one sensory modality may affect the ease with which a DLS is acquired in another modality. Not only can normal Ss be improved in their performance by prior experience in another modality, but the performance of monkeys with posterior association cortex lesions can be selectively enhanced or retarded by appropriate experience (Wilson & Wilson, 1962; Wilson, 1964). Lawrence (1952) showed that practice on an easy discrimination facilitated performance on a more difficult one involving the same stimulus dimension. He suggested that the initial training was facilitating to the degree that it enabled S to focus on the relevant stimulus dimension. Harlow & Warren (1952) demonstrated positive transfer between different classes of visual DLS habits in the monkey, and concluded that DLS is not restricted to a particular stimulus situation. Cross-modal effects on DLS require an explanation in even more general terms since the stimuli vary between modalities as well as within a modality. This argues for the ability of monkeys to attain learning strategies which are to some extent independent of a particular sensory domain.

Levine (1959) has presented a method for describing DLS performance in terms of strategies (Hs) which guide behavior. There is reason to assume (Wilson, 1965) that naive monkeys learn to attend to broad aspects of the DLS situation rather than acquire specific strategies. It was hypothesized that monkeys learn to respond to information about stimulus input and reward outcomes in systematic ways, and that transfer of these modes of response underlies cross-modal effects on DLS performance. The present experiment attempted to specify what is learned in one modality, and what is transferred to another modality, in two-object discrimination learning.

Method

Thirteen experimentally naive monkeys were used. All Ss were pretrained on one visual and three tactual object-discrimination problems, each problem to a criterion of 9 correct in a block of 10 trials. They were then randomly divided into two order groups. Six monkeys were given a series of tactual problems, followed by a series of visual problems (T_1V_2 group), and seven monkeys were given the series of visual

problems followed by the series of tactual problems (V_1T_2 group). One hundred forty-four 10-trial object-discrimination problems were given in each modality, for food reward. Four problems were given each day. Testing was carried out in a modified WGTA, as in previous studies of cross-modal effects (e.g., Wilson & Wilson, 1962). A Gellermann order was used to determine the position of the correct object on each trial, with the restriction that each of the eight possible sequences of the first three trials appear once in each block of eight problems. (This was done in order to facilitate analysis of learning in terms of the model proposed by Levine.)

Results

Ss with visual experience first (V_1T_2 group) improved significantly more on tactual problems than did the T_1V_2 group, which started training on the tactual series ($F=3.61$, $df=5/55$, $p<.01$). However, there was no comparable facilitation of visual performance in the group which had prior tactual experience (see Fig. 1). There was no suggestion in the pretraining scores that the two groups differed in initial learning ability.

In order to test the hypothesis that Ss acquired systematic ways of responding in the first modality which were transferred to the second modality, the strengths of the eight nonrandom Levine Hs were calculated for each S in both modalities. The intercorrelations between Hs were factor-analyzed using varimax rotation, separately for each order group. The first four factors accounted for 95% of variance in the T_1V_2 group, and 85% of the variance in the V_1T_2 group. These factors appear to describe the same patterns of response in both order groups: attending to position, to stimuli, to reward contingencies based on position,

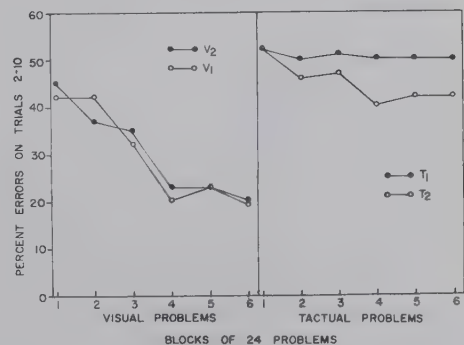


Fig. 1. Performance of the two order groups on tactual and visual problems.

and to reward contingencies based on stimuli. All Hs with loadings on a given factor for which p is less than .10 are plotted in Fig. 2 in terms of their standard errors (cf. Holzinger & Harmon, 1941). Only two Hs have loadings which conflict with the pattern of results expected on the assumption that behavior is based on selective attention to various aspects of the DLS situation. The factors accounting for the most variance in the V_1T_2 group are those described as *attending to stimulus-reward contingencies* and to *stimuli*. The T_1V_2 group, on the other hand, has most of the variance accounted for by factors described as *attending to position-reward contingencies* and *toposition*. Furthermore, these modes of response may be represented by variables from both modalities. Thus, we can explain why the V_1T_2 group showed facilitation of performance in the second modality while the T_1V_2 group did not; the V_1T_2 group acquired to a greater degree the relevant strategies based on stimuli and reward outcomes.

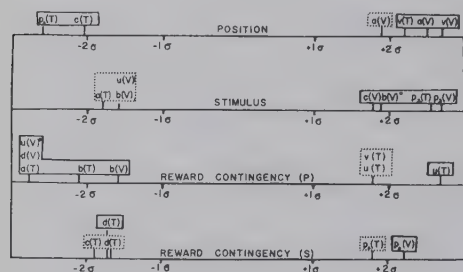


Fig. 2. Results of factor analysis of intercorrelations of Levine Hs: a (position preference); b (position alternation); c (stimulus preference); d (stimulus alternation); u (win-stay, lose-shift with respect to position); v (win-shift, lose-stay with respect to position); p^2 (learning on trial 2); p^3 (learning on trial 3). Solid boxes represent the T_1V_2 group; dotted boxes the V_1T_2 group. (T) and (V) indicate the modality in which the variable was assessed. Loadings marked with an asterisk do not fit the model described in the text.

Discussion

These results can be interpreted as showing that monkeys do not acquire specific hypotheses as described by Levine, but rather that the measured strength of various Hs reflects the extent to which an S is attending to one or another of the possible dimensions of the training experience. Some support for the idea that selective attention to relevant aspects of DLS experience is responsible for cross-modal effects on performance can be inferred from the inter-modal character of the patterns of response obtained. While this study does not speak directly to the problem of defining the processes necessary for the formation of DLS, it does suggest that both acquisition and suppression of modes of response may be important. The cross-modal results make it difficult to encompass DLS phenomena in terms of simple learning principles.

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Note

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Deafferentation in monkeys: Extinction of avoidance responses, discrimination and discrimination reversal¹

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The surgical abolition of sensation from the forelimbs of rhesus monkeys was found to produce a pronounced retardation in the rate of extinction of a trace forearm flexion CAR when view of the limbs was precluded. In an attempt to ascertain the mechanism underlying this phenomenon groups of normal and deafferented Ss were subjected to different extinction procedures in which the amount of available information concerning the response was varied. Intact and operated Ss were also compared with respect to rate of learning a "go-no go" auditory discrimination and a discrimination reversal.

Previous experiments from this laboratory have demonstrated that the surgical abolition of sensation from a monkey's forelimbs does not prevent extensive learning and performance of purposive movement under a wide variety of circumstances (Knapp, Taub, & Berman, 1958, 1963; Taub, Bossom, & Berman, 1965; Taub, Ellman, & Berman, in press). However, as might be expected, sensory denervation is by no means without effect. For example, it was found that deafferentation of either one or both upper extremities results in a retardation of the rate of acquisition of a forelimb flexion trace-conditioned avoidance response (CAR) by a factor of approximately three (Taub & Berman, 1963, 1964; Taub, Bacon, & Berman, 1965). The purpose of the present study was to examine the effect of limb deafferentation on the extinction of a trace CAR.

Method

Six rhesus monkeys with intradural deafferentation of both forelimbs (C2-T3) and five normal monkeys were conditioned in a trace avoidance situation identical to that employed in previous studies. The CS was a click, the CS-US interval was 3-1/2 sec., and in the absence of a right forelimb flexion between a lamp and photoelectric receiver located 5 in. above a board upon which the arm normally rested, shock was delivered to the left ear of the seated S for an additional 3-1/2 sec. During training the limbs could not be seen. Twenty trials were given each session with a mean intertrial interval of 75 sec. After reaching a minimum acquisition criterion of 80% on two consecutive days, two Ss from each group were given five additional conditioning sessions. The remaining animals were overtrained for 30 days. During this period it was required that a stringent stability criterion be maintained. Following overtraining an extinction series was begun and continued till a criterion of 80% no-response for one session was reached.

Subsequently, four additional groups were added to

the study. For all these Ss the CS during acquisition was a response terminable buzzer. After the usual learning criterion had been reached there followed 30 overtraining days. For four normal and three deafferented monkeys the procedure was changed during extinction; the buzzer could not be terminated and thus always continued for a full 7 sec. One might say that these animals were being informed that the CR was no longer effective. Therefore, these were viewed as "Correct Information" (CI) Groups. The remaining Ss, two normals and one deafferent, were allowed to continue terminating the buzzer during extinction, thereby receiving secondary reinforcement even though the primary negative stimulus would not have been delivered if the CR were not made. This was viewed as a "False Information" (FI) situation. The original click, trace-conditioned Ss were considered, within this paradigm, to constitute "No Information" (NI) Groups.

Since extinction phenomena are presumably involved in learning a "go-no go" discrimination and especially a discrimination reversal, the next phase of the investigation was undertaken in an attempt to determine whether there is a difference between normals and deafferents in this respect. Following extinction, all buzzer Ss were reconditioned. There was no difference in the rates at which normals and deafferents reached acquisition criterion. A pure tone, CS⁺, was then introduced on half the trials in random order. On the buzzer trials the task for S remained the same. If a response was emitted within 3-1/2 sec. after CS onset, shock was avoided. On the tone trials, however, S was required to not respond. The CS could not be terminated and each time the photoelectric beam was interrupted a brief but intense shock was delivered to the left leg. After a criterion of 80% correct response on both buzzer and tone trials had been reached on two consecutive days, the reinforcement contingencies were reversed. The Ss now had to respond to the tone but not to the buzzer in order to avoid shock.

Results

Table 1 contains a summary of all the data from the present experiment. The upper portion of the table indicates that the extinction of a trace CAR proceeded 4.5 times more slowly for deafferents than for normals ($p < .05$, U test); approximately the same factor by which acquisition was retarded. The "Correct Information" procedure speeded extinction for both types of S, but to a much greater extent for deafferents, who thus extinguished as rapidly as did the normals. The ratio of the difference in rates of extinction between "No

Table 1. Mean Days Prior to Reaching Extinction, Discrimination and Discrimination Reversal Criteria for All Deafferented and Intact Groups^a

Group	n	Deafferented	n	Intact
NI Click	6 ^b	56.0	5 ^b	12.4
CI Buzzer-nonterm.	3	2.7	4	2.8
FI Buzzer-term.	1	89	2	51.0
Discrim.	4	2.3	6	5.7
Discrim. Reversal	2	23.5	4	12.7

a. Criterial days are not included in these figures.

b. Two Ss were given 5 days of overtraining; the others 30 days.

Information" and "Correct Information" Groups for normals was approximately 4, but for deafferents it was 21. The ratios differ by a factor of approximately 5. (Results from the "False Information" Groups are, as yet, too scanty to provide a basis for interpretation.)

The discrimination and discrimination reversal results are summarized at the bottom of Table 1. Of most significance here is the fact that deafferents were able to learn the discrimination and in the two cases tested to date, the discrimination reversal. Surprisingly, normals and deafferents did not differ significantly ($p > .05$, U test) in the number of days that were required to achieve criterial performance on the discrimination. However, it may be that these data are contaminated by a possible differential tendency between normals and deafferents to generalize from buzzer to tone. Thus, it would probably be more valid to compare the results from the discrimination reversal situation where this problem does not arise; but they are, at present, insufficient for this purpose.

Discussion

The initial data in this study were collected from the trace-conditioned groups. Two hypotheses were considered as possible explanations for the observed increase in the resistance to extinction of the deafferented Ss. An "Information Hypothesis" was based on the fact that deafferented monkeys would have less information concerning the nature of movements of an unseen extremity than would intact Ss. Thus, for example, accidental performance of non-avoidant movements, which should hasten the process of extinction, would not be as readily discriminated by deafferents as by normals. This notion will be recognized as being closely related to the Generalization Decrement Theory of Extinction. Alternately, it was considered possible that the prolonged period required for the extinction of the trace CAR in deafferents was due to the well-known supersensitivity that develops in deafferented spinal motoneurons (Teasdale & Stavsky, 1953). Thus, Ss with a deafferented limb might have been less able to inhibit well-learned CRs of that extremity than intact Ss. This hypothesis may be viewed as a type of indirect application of the Inhibition Theory of Extinction to the present experimental situation.

In order to determine which of the two hypotheses constitutes a more appropriate interpretation of the trace CAR data, the two "Correct Information" Groups

were added to the study. Our reasoning was that if the "Information Principle" is of greater significance than the "Excitation Principle," then an increase in information ought to have a much more profound effect on the rate of extinction of the deafferents than of the normals. The results provide support for the "Information Hypothesis," at least insofar as it applies to the present study. By supplying additional, though "indirect," information concerning the CR to deafferented Ss, their resistance to extinction became no different from that of normal Ss similarly treated. In general, we might say that the more information that deafferents have concerning unseen movements, the more similar their behavior becomes to that of normals.

In the present situation, then, information was clearly an extremely powerful variable in the control of behavior. A reinforcement theory could explain very simply the differences within the deafferented groups or within the normal groups. But in order to account for the differences between the normal and deafferented groups, informational concepts would have to be added to the formulation.

The fact that monkeys can be trained to respond differentially to two related stimuli with an unseen limb from which sensation has been eliminated, and then learn to reverse the pattern of response should be remarked. This conditioned behavior is more complex in certain respects than any noted in earlier deafferentation experiments from this laboratory. We thus have additional confirmation here for our previously stated view that the primate CNS is capable of a great deal more autonomy and independence from the periphery in the acquisition and maintenance of behavior than has generally been thought possible.

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Note

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Operant discrimination as a function of rate of stimulus alternation¹

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Three groups of rats were given operant discrimination training in which S^d - S^Δ alternation occurred 3, 6, or 12 times per min. Only the 3/min. group learned to inhibit S^Δ responses. The nonlearning of the 6/min. and 12/min. groups was discussed in terms of adventitious reinforcement of S^Δ responses.

In the experimental procedure used to investigate differential conditioning in an operant situation, a number of stimuli, each signaling a particular schedule of reinforcement, are repeatedly presented to the organism. In the typical case, two stimuli are employed, one (S^d) associated with reinforcement, the other (S^Δ) with nonreinforcement. When the alternation of the discriminative stimuli is programmed independently of the S's behavior, the schedule of S^d - S^Δ alternation employed can vary along several temporally defined dimensions. The purpose of the present study was to investigate the effects of one temporal parameter, the frequency of S^d - S^Δ alternation, on the formation of an operant discrimination.

Method

The Ss were 12 experimentally naive male Holtzman rats, 120-130 days old at the beginning of the experiment. They were maintained at 80% of their free-feeding weight for 14 days prior to, and throughout, the experiment. The apparatus consisted of two identical Gerbrands model C rat test chambers enclosed in picnic ice chests. The response panel in each was equipped with a retractable lever, two green one-inch cue lights, and a food cup. A small houselight was mounted above each chamber. A feeder which dispensed 45 mg Noyes pellets, a small relay and a speaker were mounted behind each response panel. Throughout the experiment, S^d was the click produced by 10/sec. operation of the relay and S^Δ was the 10/sec. flashing of the cue lights. White noise was continuously presented through the speaker. The two chambers were controlled by standard programming equipment located in an adjacent room.

On the day before discrimination training began, each S was given 60 free pellets on a VI 1 schedule, with the bar retracted. The bar was then extended into the chamber and each S was allowed to make 40 reinforced responses. Neither S^d nor S^Δ was presented during this session. Discrimination training was run for 20 consecutive days. Each daily session lasted 16 min. and was divided into 8 min. each of S^d and S^Δ . Every response during S^d (R^d) and no response during S^Δ (R^Δ) was reinforced. Each session began with onset of the houselight, extension of the lever into the chamber, and either an S^d or S^Δ period. The stimulus which defined

the first period was randomly determined, and the two discriminative stimuli simply alternated throughout the session. Three groups of four Ss, formed by random assignment, differed in the number of S^d - S^Δ alternations they received during training. Group 1 had 12 alternations/min. (5-sec. periods), group 2 had 6 alternations/min. (10-sec. periods) and group 3 had 3 alternations/min. (20-sec. periods). Three dependent variables were recorded for each session: number of R^d , number of R^Δ , and a derived discrimination index, $DI = R^d / (R^d + R^\Delta)$, the proportion of the total responses that were R^d s.

Results

As shown in the top panel of Fig. 1, only group 3 displayed any appreciable learning in terms of DI, reaching an apparent asymptote of about .80, whereas

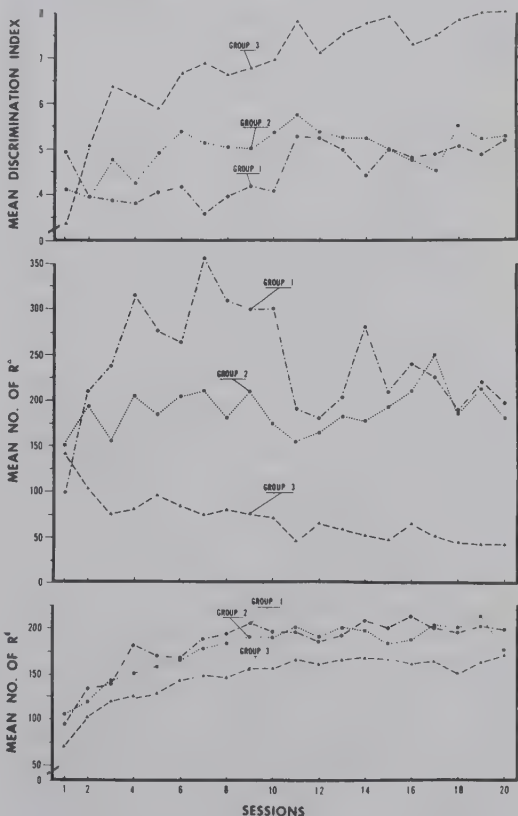


Fig. 1. Mean discrimination index (upper panel), mean number of responses during S^d (middle panel), and mean number of responses during S^Δ (bottom panel) for the three groups.

the other two groups were performing at about .50 after 20 days. A days-by-groups analysis of variance on these data yielded significant effects for groups ($p < .01$), days ($p < .01$) and the days-by-groups interaction ($p < .01$). The middle panel of Fig. 1, showing the number of R^A across sessions, indicates that only group 3 showed any inhibition of S^A responding, while group 1 performed especially poorly on days 2-10. Analysis of variance of these data again yielded significant groups ($p < .01$), days ($p < .05$) and days-by-groups ($p < .05$) effects. The bottom panel of Fig. 1, number of R^d across sessions, shows all groups increasing their S^d responding during training, with group 3 making fewer R^d s than the other groups. Analysis of variance of these data showed the groups ($p < .05$) and the days ($p < .001$) effects to be statistically reliable.

Discussion

The most interesting aspect of the results was the failure of groups 1 and 2 to learn to inhibit lever responses during S^A ; these groups had R^A asymptotes that were far above that of group 3, and group 1 showed a striking increase in S^A responding over the first seven sessions, suggesting the action of a learning process. Among various possible interpretations of this high incidence of S^A responding, we find the most plausible to be in terms of adventitious reinforcement.

Assuming a random distribution of R^A s across stimulus periods, Ss receiving a higher rate of stimulus alternation would be more likely to have a given R^A followed by S^d onset (itself a conditioned reinforcer after some training) and a reinforced R^d than Ss having a low alternation rate. The reinforcement following R^d would strengthen preceding R^A s as well as R^d s, tending to produce rapid chains of responding. In addition, viewing the independent variable in terms of length of a given stimulus period rather than the frequency of stimulus change, it seems likely that the differential probability of such adventitious reinforcement was increased by the greater opportunity for extinction to occur in the longer S^A periods of group 3 and the possibility that frustration produces a temporarily heightened rate of lever responding very soon after S^A onset.

This interpretation would suggest that the frequent stimulus alternation groups, particularly group 1, learned to emit chains of lever presses having short interresponse times during S^A . Such phenomenon would also explain the obtained R^d differences as due to a generalized tendency, in the groups that did not learn to inhibit R^A s, to respond in bursts of lever presses.

Note

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Resistance to extinction after continuous and partial reinforcement in basenji puppies¹

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Eighteen basenji puppies each received 3 pretraining, 36 training, and 30 extinction trials, 1 trial per day, in a right-turn alleyway. Nine Ss had a 100% reinforcement schedule during pretraining and training, 9 had 100% during pretraining and 50% during training. The reinforcer was 1 min. of exposure to a passive person. A statistically significant decrement in start, running, and goal speed occurred during extinction, as expected. But, unexpectedly, resistance to extinction was unaffected by schedule of reinforcement.

Previous findings have indicated that a passive person functions as a positive reinforcer in the young dog. Basenji puppies exhibited orderly increases in running speed when contact with a passive person was contingent upon running to the person (Stanley & Elliot, 1962). Shetland sheep dogs achieved higher terminal running speeds with a passive person reinforcer under a high deprivation condition than under a low deprivation condition (Bacon & Stanley, 1963). Presence, absence, and reintroduction of a passive person produced, respectively, the acquisition, extinction, and reacquisition of a running response in Shetland sheep dogs (Stanley, Morris, & Tratner, 1965) and isolated beagles (Stanley, 1965). Thus, the passive person reinforcer affects canine behavior in ways consistent with the control exerted by, e.g., a food reinforcer in rats.

The purpose of this study was to extend our knowledge concerning the passive person reinforcer. First, basenji puppies were used as Ss because this breed had not been previously studied during extinction after training with a passive person reinforcer. Second, half the Ss were trained with an intermittent or partial reinforcement schedule. Partial reinforcement schedules usually produce greater resistance to extinction than 100% schedules. This phenomenon, generally termed the partial reinforcement effect (PRE), has been demonstrated in a variety of species, both vertebrate (Lewis, 1960) and invertebrate (Wyers, Peeke, & Herz, 1964), and with various reinforcers both consumable and nonconsumable (Lewis, 1960).

Method

The Ss were nine male and nine female purebred basenjis from stock of The Jackson Laboratory and were 52 days of age at the start of the experiment. They had been weaned between 31-35 days of age, and were housed six pups per large indoor pen. Feeding came 4 hr. before and 2 hr. after each daily experimental session. Care-taking was done by personnel other than E.

The apparatus was a right-turn L-alleyway, open at the top. The long arm of the L was 212 in. long.

Attached to it was a short arm, 60 in. long. The floor was gray plywood, 24 in. wide, and the walls were framed white cloth 32 in. high. Attached to the other end of the long arm was an enclosed gray start box, 32 in. long, 24 in. wide, and 22 in. high, the floor of which was sufficiently depressible by S's weight to operate a switch. The start box door was hinged at the top and opened out into the alleyway. A gray wooden guillotine door was located 146 in. from the start box door and prevented S from leaving the end of the long arm which together with the short arm served as the goal box.

Three automatically controlled 0.1 sec. Standard Electric timers provided three measures of Ss' performance, defined by the location of controlling switches in the apparatus. Starting time was the time between E's opening the start box door and S's entry into the alley, alley running time was the time between S's entry into the alley and its breaking the first photoelectric beam 176 in. from the start box door, and goal running time was the time between S's breaking the first beam and its breaking the second beam 36 in. from the end wall of the goal box.

Three Ss in each pen were randomly assigned to the 100% reinforcement (C) condition, the remaining three Ss, to the 50% reinforcement (P) condition. Throughout the experiment, each S received one trial per day. In the pretraining phase (three trials), all Ss were run under the C condition and accustomed to running by being started progressively farther away from the goal box. In the training phase (36 trials), the C Ss received 1 min. of exposure per trial in the goal box to E, as described by Bacon & Stanley (1963). The E, wearing a white "lab" coat, sat with his back against the end wall and his body extending into the goal box about 30 in. The P Ss received 1 min. of such exposure on 50% of the trials and 1 min. of confinement in an empty goal box on remaining trials. Reinforced trials for the P condition were assigned randomly with the following restrictions: (a) the first and last training trials were reinforced, and (b) no more than three reinforced or nonreinforced trials occurred in succession.

Details were as follows: The S was placed in the start box and approximately 10 sec. later the start box door was opened. If S failed to interrupt the second photoelectric beam within 2 min. after passing through the first photoelectric beam, the trial was terminated and 120 sec. was recorded as goal running time. This was necessary on a total of only six trials (four different Ss) and only during the early training trials.

In the extinction phase (30 trials), the same procedure

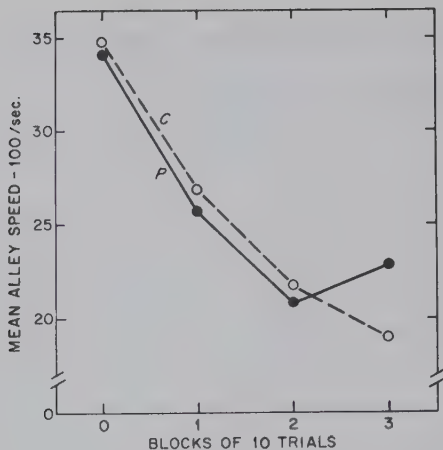


Fig. 1. Mean alley running speed during the last 10 training trials (0) and during blocks of 10 extinction trials (1-3) for the continuous (C) and partial (P) reinforcement groups.

as described for training was followed except the goal box was empty on all trials for both the P and C groups.

Results and Discussion

All time measures were converted to relative speed scores—100/time in sec. Starting, alley running, and goal running speeds were analyzed separately by appropriate analyses of variance. Analyses of the pretraining response speeds showed no significant main effects or interaction of housing (three pens) and reinforcement schedule assignment ($ps > .10$), indicating that Ss were not fortuitously housed or assigned to treatment in a biased manner.

To assess improvement in training performance, means over blocks of six trials for each speed measure were taken for each S. Separate analyses of variance were carried out on each speed measure to determine any main or interactive effects of trial blocks (T), reinforcer schedule (R), and housing (H). In each analysis only the T condition proved significant ($ps > .001$). Start, running, and goal speed means increased over trial blocks but neither their terminal levels nor rates of increase were differentially affected by R or H. Schedule of reinforcement thus had no reliable effect on the Ss' performance in the alleyway during training.

To assess decline in extinction performance, four means were computed for each S on each measure, one mean per block of 10 extinction trials and one mean for

the last 10 training trials. Analyses of variance similar to those carried out on the training data indicated that only the T effect was significant ($p > .001$) for each speed measure. All other effects were statistically non-significant ($ps > .10$).

All three speed measures yielded the same general result graphically and statistically. Figure 1 portrays this result for the alley running speed measure. First, the permanent omission of the passive person reinforcer brought about the usual extinction effect—a decline in performance. These data confirm and extend previous findings on extinction in the young dog (Stanley, Morris, & Trattner, 1965; Stanley, 1965). Second, no discernible PRE occurred. The P and C groups showed equal resistance to extinction. Whether this failure is due to species, breed, age, nature of reinforcer, or procedure is not clear. It should be noted, however, that more recent unpublished data indicate that basenjis run more slowly than other breeds (e.g., Shetland sheep dogs, terrier X beagle hybrids) with a passive person reinforcer. This finding suggests that in basenjis the passive person reinforcer may be functionally equivalent to a small amount of food reward in rats. Hulse (1958) and Wagner (1961) have shown that the PRE is greatly reduced if not eliminated with small amounts of food reward.

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Note

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Adaptation and persistence of adaptation to a cold stressor in mice¹

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To determine their ability to adapt to a cold stressor, C3H mice were immersed to the neck daily in a 45°F water bath from 36-42 days of age. Following this adaptation procedure, the mice were divided into four groups and again immersed at either 1, 7, 14, or 21 days later. The results indicate that mice adapt very rapidly to cold and maintain an increased tolerance to cold for at least 21 days.

In recent years, an increasing number of studies have been concerned with the effects of early stress on later resistance to stress. Some of these studies have interpreted their results as showing that early stimulation alters later resistance to stress (Levine & Otis, 1958; Denenberg & Karas, 1960; Schaefer, Weingarten, & Towne, 1962), while others have reported no change in later resistance (Ader, 1959; McMichael, 1961). Campbell & Riccio (in press) have suggested that a possible source of these divergent findings may be the inability to adequately specify and control the stimuli used as stressors in these studies. Consequently, they developed a new technique for studying the effects of cold exposure upon later resistance to cold which allowed them to better specify and control the stressor stimuli, in this case, cold. Their results showed that both 25 and 100 day old rats are able to rapidly adapt to cold and maintain an increased resistance to cold for some time afterwards.

This purpose of the present study was to determine whether this technique is useful for studying adaptation and persistence of adaptation to cold in another species, the mouse (*Mus Musculus*).

Method

The Ss were 90 male and 90 female C3H mice from 26 litters.

The apparatus consisted of a Forma Temp water bath; differential sensitivity $\pm .02^{\circ}\text{C}$. Plexiglas containers, scaled to the size of the mice, were used to restrain Ss during immersion in the water bath. Each container was perforated with a number of holes to allow water to circulate freely around the Ss. An Ellab Universal Thermocouple Thermometer (type TE3; differential sensitivity $\pm 0.1^{\circ}\text{C}$) with a type RM6 probe was used to measure colonic temperatures.

At 36 days of age, 40 males and 40 females, selected according to a modified split-litter design, were removed from their cages, placed in the restraining tubes, and immersed to the neck in the 45°F water bath for 2 min. 47 sec. This immersion interval was one which was easily survived by all Ss, and was 1/4 of the immersion interval which 50% of Ss could survive at this water temperature (Nagy, 1965). Following removal from the water bath, Ss were placed in individual

semi-enclosed plastic cages (5 x 3-1/2 x 3 in.) at room temperature (74°F) for a 2-hr. period. Ss were then returned to their home cages. This procedure was followed daily through 42 days of age. On the first, third, fifth, and last day of adaptation, colonic temperatures were recorded immediately after removal from the water bath, 5, 15, and every 15 min. thereafter until S returned to 35°C colonic temperature. On the last day of adaptation, 10 male and 10 female littermate controls received the same treatment as the experimental Ss.

Following immersion on the final day of adaptation, the 80 adapted Ss were assigned to one of four retention groups consisting of 10 males and 10 females on the basis of their colonic temperature immediately following removal from the water bath on that day, so that the mean temperatures were nearly the same for all groups. Persistence of adaptation was tested 1, 7, 14, and 21 days following original adaptation, with each group being immersed on only one of the retention days. Correspondingly, Ss were 44, 50, 57, and 64 days of age at testing. Separate control groups of 10 male and 10 females, littermates of the adapted Ss, were immersed on each retention day. Colonic temperatures were recorded for all groups on all retention days.

Results and Discussion

The two measures of adaptation which were used were colonic temperature of Ss immediately upon

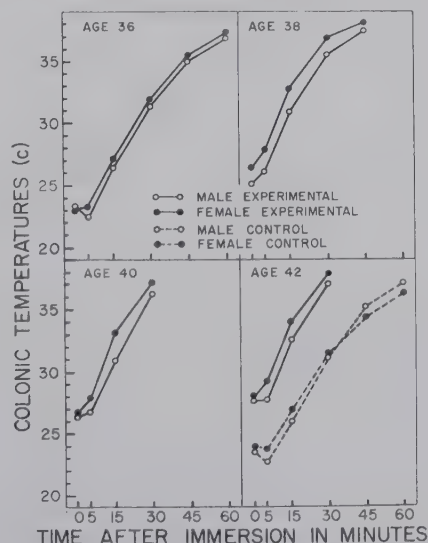


Fig. 1. Mean post-immersion and recovery temperature of Ss during adaptation between 36-42 days of age.

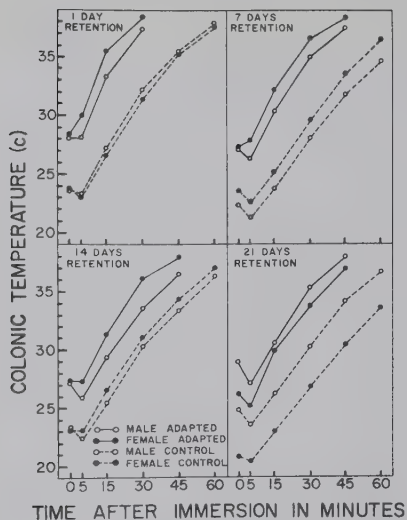


Fig. 2. Mean post-immersion and recovery temperatures of Ss after 1, 7, 14, and 21 day retention intervals following adaptation at 36-42 days of age.

removal from the water (post-immersion temperature) and the time required for Ss to return to 35°C colonic temperature (recovery time).

Figure 1. shows the mean colonic temperatures of Ss following immersion for every other day of the 7 day adaptation period. On the final day of adaptation, adapted Ss had higher post-immersion temperatures ($F=48.56$; $df=1,96$; $p<.001$) and faster recovery times ($F=117.95$; $df=1,96$; $p<.001$) than controls. There were no sex differences for either post-immersion temperature ($F=0.52$; $df=1,96$) or recovery times ($F=1.88$; $df=1,96$) on day 42. However, over the course of the adaptation period, females recovered faster than males ($F=14.87$; $df=1,312$; $p<.001$) but showed no difference in post-immersion temperatures ($F=2.86$; $df=1,312$).

Prior to the retention tests, the four adapted groups were analyzed for both post-immersion temperatures and recovery times on the last day of adaptation. Analyses of variance revealed no differences between any of the groups on either measure, suggesting that each group had adapted equally well to the cold.

Figure 2. presents the mean colonic temperatures of both experimental and control Ss following removal from the water bath on their respective retention days. Overall analyses of variance showed that previously adapted Ss had higher post-immersion temperatures ($F=170.92$; $df=1,144$; $p<.001$) and faster recovery times ($F=195.95$; $df=1,144$; $p<.001$) than controls. T-tests showed that at all retention intervals, adapted male and female Ss had higher post-immersion temperatures (all $p<.001$) and faster recovery times (all $p<.01$) than their respective controls. T-tests also revealed that at the 21 day interval, male adapted Ss had higher

post-immersion temperatures than adapted females ($p<.01$), while the control males had higher post-immersion temperatures ($p<.001$) and faster recovery times ($p<.001$) than control females.

It is clear from this experiment that mice at 36-42 days of age adapt very quickly to cold immersions, as reflected by higher post-immersion temperatures and faster recovery times. This finding is in agreement with cold adaptation obtained with young rats (Riccio & Campbell, in press). The retention data demonstrate that adaptation to cold persists for at least 3 weeks following original adaptation in mice, again in agreement with results reported for young rats (Riccio & Campbell, in press).

The present results show a difference in tolerance to cold between the sexes as Ss increase in age. At 64 days of age, the previously adapted females have significantly lower post-immersion temperatures and longer recovery times than the adapted males. At all other ages, females were equal to or better than the males in both measures. Evidence that this decrease in tolerance to cold is due to age and not merely to poorer persistence of adaptation after 21 days in females than males, is provided by examination of the control groups at the various ages. Like the adapted females, control females are equal to or better than control males except at 64 days of age, where the males are significantly more tolerant to cold than the females.

The results of the present experiment should also serve as a caution to experimenters who vary water temperature as a differential source of motivation in water mazes. The present study shows that upon repeated exposure to cold water, mice can adapt within a few days, being not nearly as affected by the cold as on the first day or as controls are.

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Note

1. The research reported here is a portion of a Ph.D. dissertation, Princeton University, 1965, and was supported in part by N.I.M.H. Grant M-1562 to B. A. Campbell. I thank Dr. Campbell for his assistance in all phases of this research.

Habit reversal in the crow, *Corvus Americanus*

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Two crows were run on multiple reversals of a simultaneous visual discrimination problem. The crows showed a marked progressive decrease in errors to criterion over the series of reversals. Their performance appeared to be superior to that of more primitive but more widely studied avians such as the pigeon. The crows' performance also differed from that found in the rat in that the latter's performance in reversal situations has generally been characterized by an initial increase in errors per reversal followed by a progressive decrease.

Despite the fact that the crow is considered to exemplify one of the most advanced levels of avian brain development (Cobb, 1960), there have been very few experimental studies of its learning capacity. Such studies may have special comparative significance in the light of the fact that the pigeon, the avian subject generally used in learning studies, is considered among the lowest group of birds on the basis of comparative brain development (Cobb, 1960). Thus, a proper assessment of the learning capacity of class *aves* cannot be made until a more advanced representative of the class has been studied extensively.

Previous work on the crow (Coburn, 1914; Coburn & Yerkes, 1915) indicated that they learn visual discriminations readily and also that they can learn to respond to the relationship of "the first open door on the right" or "the first open door on the left," in a ten-door multiple-choice apparatus. These investigators did encounter some difficulties in training, however, as they reported being unable to induce the crows to make more than 20 responses per day, and frequently had to modify their procedures in progress in order to avoid "discouraging" the animals. The technique and the results of a study of repeated visual habit reversal in the crow are described below. The reversal task was chosen because it has been shown to be a useful tool for assessing comparative learning ability (Bitterman, 1965).

Method

The Ss were two male crows (*Corvus Americanus*), one to two years of age. They were maintained on a limited ration of 4 oz. of canned dog food per day throughout the course of pre-adaptation as well as the experiment proper.

After a period of six weeks in the laboratory, during which the crows were adapted to eating in E's presence, their daily ration was placed in a large four-wheeled unpainted plywood box, 25 x 29 x 19 in. high, fitted at one end with a guillotine entrance door made of vertically oriented wire bars set 1/2 in. apart. This box was pushed up against the cage door, and after the crows entered the box without hesitation for seven

consecutive days, dog food was placed in a small wire basket mounted on the outside wall of the box. Access to the food was provided by a 1 x 2-1/2 in. opening fitted with a solenoid-operated guillotine door, and the crows were adapted to the procedure of eating whenever the solenoid was operated.

The experiment proper began when the crow, after entering the box, was wheeled into the experimental room and the wire bar door placed up against two Lehigh Valley transparent pecking keys set 2 in. apart. Directly behind each pecking key was mounted a Grason-Stadler stimulus projector with a viewing surface 1-1/2 in. square. The stimuli projected were sets of three white stripes on a black field; one set was oriented horizontally, the other vertically.

The apparatus was designed so as to perform the following operations automatically: (1) present horizontal and vertical sets simultaneously at each stimulus presentation, in random arrangement spatially; (2) program all stimulus onsets with a random arrangement of intertrial intervals of 30, 45, 60, and 90 sec.; (3) terminate the presentation of stimuli whenever a key was pecked; (4) reinforce each correct peck by allowing access to the dog-food basket for 3 sec.; (5) perform "delayed correction" (see below); and (6) record on an Esterline-Angus event recorder the onset, duration, and termination of stimuli, as well as the occurrence, position, and correctness of each response.

During training, each S received 80 trials per day five days per week. On acquisition, one S was reinforced for pecking at the vertical stripes, the other for pecking at horizontal. When criterion of three successive training sessions at 90% correct or better was reached, the next session was a reversal of the acquisition condition. Subsequently, the criterion for successful habit reversal was 16 or more correct responses in the last 20 of each session. When criterion was met, another reversal was programmed on the following day, which meant that generally some small degree of "overlearning" was involved on each reversal.

In order to eliminate the possibility of a "spatial fixation," wherein the animal could be rewarded 50% of the time by responding to either the right or left stimulus regardless of visual differentiation, a delayed correction procedure was established, wherein the stimuli would be presented in the same spatial position until a correct response "stepped" the stimuli to the next unit in the sequence of random positions. Thus, continued responding to the same side would result in 0% rather than 50% reinforcement.

Training was continued until one S had reached criterion on 12 reversals, the other on 15. At this point, the birds began to leave their daily ration uneaten,

and training was suspended on the surmise that they were ill. They both died within 10 days of a respiratory infection.

Results

As can be seen in Fig. 1, number of errors to criterion for each reversal for each S, both birds showed evidence of improvement over the course of the series of reversals. Moreover, the magnitude of the improvement was considerable, involving a change from 180 errors on the first reversal to less than 20 errors per reversal at the peak of performance. One can only conjecture as to whether or not the birds were performing at asymptotic level when the series had to be terminated, but there certainly was a leveling off on the latter reversals, with S 1 never besting his performance of the ninth reversal and S 2 reaching a similar peak on the tenth.

The crow's performance was also characterized by a high terminal level of correct performance on each reversal. The crows generally responded at a level of 90 to 100% correct on the last 20 trials before reversal, performing above our criterion. Thus, once the perseverative response to the previously positive stimulus was extinguished, the new correct response became established very quickly. It was the perseverative response tendency which decreased with successive reversals.

Discussion

On the basis of the closest comparisons that can be made with available data, performance of the crow

appears to be superior to that of the pigeon, which only has shown improvement on successive visual reversals under conditions designed to facilitate discrimination to a greater degree than those employed in the present study with crows. Bullock & Bitterman (1962) found evidence of improvement only when a specialized "guidance" training procedure was used which signalled the correct response by presenting it in isolation after a preset number of perseverative errors. Stearns & Bitterman (1965) found improvement when there was direct association of the actual feeding response with the discriminative cue, whereas the curves they show for the more standard single feeding location situation as used with crows shows no superiority of the last reversal as compared to the first one.

Although the crow's performance might be considered as similar to the rat in that they both show progressive improvement in habit reversal, the trend of the crow's performance differs in at least one important respect from that of the rat. The latter shows an initial increase in the number of errors per reversal on early reversals followed by subsequent improvement to a point where they are making fewer errors than they were initially (Bitterman, Wodinsky, & Candland, 1958), as opposed to the drop in errors right from the outset shown by the crow. There is no a priori means of deciding which pattern is "superior." Perhaps at this point, the crow's performance should best be characterized as "non-mammalian" rather than sub-mammalian, a characterization consistent with the suggestion made as to the evolutionary status of birds by Romer (1962). The crow has proven to be amenable to experimentation using current techniques and certainly would repay further study designed to evaluate its performance in a variety of learning situations.

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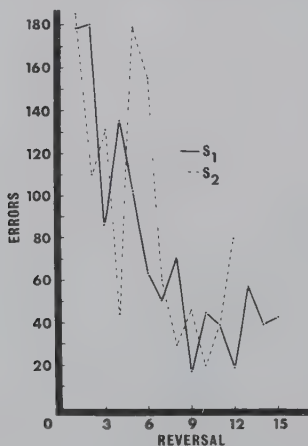


Fig. 1. Number of errors to criterion for each reversal for each S.

Backward association in pigeons¹

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After three pigeons learned two paired-associate color sequences, they were tested with the colors in each sequence reversed. These tests showed that the pigeons had formed a backward association, and that the forward association was stronger than the backward association, but not significantly so.

In a recent paper on human verbal learning, Asch & Ebenholtz (1963) conclude that forward (a-b) and backward (b-a) associations are of equal strength. They argue that the reason most studies do not support this conclusion is that the b-terms are more "available" to recall than the a-terms by virtue of training procedures (Asch & Ebenholtz, 1963, Experiment 1).

It would be of interest to compare man with lower animals in associative symmetry (or asymmetry) and to examine the role of availability in sub-human species. The prerequisite to such a study is the demonstration that lower animals are capable of forming a backward association. To the best of my knowledge, backward association has never been demonstrated in birds. Thus, the present experiment examines the ability of birds (pigeons) to form a backward association.

Procedure

Three pigeons were taught two color sequences. They were then tested for backward association with the colors in each sequence reversed. The paradigm was $A \rightarrow X$ and $B \rightarrow Y$ in training and $X \rightarrow A$ and $Y \rightarrow B$ in backward testing, where A and B represent stimulus (S) colors and X and Y response (R) colors. A, B, X, and Y were selected from the colors red, green, blue and yellow. In training, pigeons were presented with A or B followed by X and Y. In backward testing, X or Y was followed by A and B.

Pigeons I and II (II died) were randomly assigned to the color combinations red $\rightarrow$ green, blue $\rightarrow$ yellow, and pigeons III and IV to the reverse combination (green $\rightarrow$ red, yellow $\rightarrow$ blue). They pecked lighted buttons arranged in a triangle with one stimulus-button on the bottom and two response-buttons on top. The steps in the training procedure were as follows: (1) S-light came on. (2) Pigeon pecked it. (3) S-light went off and the two R-lights came on. (4) If pigeon pecked the correct response-light, food was delivered in 50% of the trials. The other 50% were unreinforced. (5) If pigeon pecked an incorrect R-light, an overhead light went off, leaving the bird in darkness for about 10 sec. (6) Back to step (1). A training session, one per day, consisted of 56 trials, 7 blocks of 8 trials. The eight possible combinations of stimulus colors (A or B), response-light positions (X on right, Y on left or vice-versa), and

reinforcement or nonreinforcement appeared in random order in each block.

The initial plan was to train all birds to a criterion of 90% correct for two sessions in a row, under a system where total pecks (56) were constant and total correct pecks varied. But after 100 sessions, since pigeons III and IV had learned very little, the criterion was changed to 75% for two sessions in a row, under a system where the number of correct pecks (56) was constant and total pecks were permitted to vary.

After a bird reached criterion, it was tested: first in the backward direction ($X \rightarrow A$, $Y \rightarrow B$), then forward (in training order), then backward again. The test trials were unreinforced; however, incorrect responses caused the overhead lights to go off for 10 sec. In backward testing, one of the previous response colors (X or Y) appeared in the bottom button and the two previous stimulus colors (A and B) appeared in the top buttons. The pigeon first pecked the bottom color, previously a response color but now in the stimulus position, and then had a choice between two colors in the response positions that had previously been stimulus colors. Each test was given on the day after the criterion had been reached and consisted of 28 trials. Between tests, each pigeon was retrained to criterion.

Results

Table 1 shows the test scores, i.e. the number of correct responses in 28 backward association trials and the p value as compared to chance performance. Pigeons I and III showed reliable evidence of having formed a backward association. Although pigeon IV did relatively poorly on the backward association tests, when the data from the three pigeons are combined, the proportion of correct responses in the backward tests is greater than chance. The poor performance

Table 1.
Number of Correct Pecks in 28 Trials in Each of Three Tests

	Pigeon			
	I	III	IV	Combined
No. training sessions	53	123	155	
1st test, backward	18	17	14	$p > .10$
2nd test, forward	25	23	16	$p < .01$
3rd test, backward	18	19	18	$p < .05$
Both backward tests	$p < .05$	$p < .05$	$p > .10$	$p < .02$
Difference	$p > .10$	$p > .10$	$p > .10$	$p > .10$

Note: The p values are for the null hypothesis that the probability of pecking correctly was .50 on each trial, except in the bottom row, where p is for the null hypothesis that the difference is zero between proportion of correct backward and forward test trials. In the "combined" column, p was obtained from the entries in the other three columns by the formula $-2 \sum \ln p \cdot x^2/6$.

of pigeon IV may have been caused by erratic behavior which was exhibited throughout the experiment.

Discussion

Three things may be concluded from the data: first, that pigeons are capable of forming associations between colors; second, that these pigeons formed a backward association; and third, that the forward association was not significantly stronger than the backward association.

It is likely that these results are related to the manner of training; specifically, requiring the pigeon to peck at the stimulus color before pecking at the response color. In terms of the Asch-Ebenholtz studies, this procedure may help to equalize the "availability" of the S- and R-colors as contrasted to a procedure which requires pecking at R only. The present procedure was adopted in the belief that it would enhance the likelihood that the pigeons would pay attention to the S-color. Using a procedure which requires pecking the R-color only might result in the backward association being significantly weaker than the forward association.

It could be argued that the blackout after an incorrect response in backward testing strengthened the backward association. If the blackout explanation is correct, then the number of correct responses in the last half of the tests should be greater than those in the first half. This explanation is not supported by the data: the total number of correct pecks in the first 14 testing trials

over all pigeons equaled the total correct in the last 14 trials. The same result was also true for the first versus the last 10 trials, as well as for the first versus the last 5 trials. Therefore, it would appear that the blackout during testing did not strengthen the backward association.

It should be noted that the results of this study are based upon intra-individual performance and not upon comparisons between pigeons. Therefore, the loss of pigeon II and the erratic behavior of pigeon IV do not destroy the conclusion drawn from the experiment.

The capacity to form backward associations may be used to evaluate differences in intelligence or learning ability, in much the same way that Bitterman (1965) has used the tasks of habit reversal and probability learning for evolutionary comparisons of learning ability.

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Note

1. This study started as a Science Fair project at Martin Junior High School, Raleigh, North Carolina, in 1962. I am indebted to Norman Guttman and Slater E. Newman for advice and to Gilbert Gottlieb and my father, Clifton Gray, for guidance. I am also indebted to Ray Moore for instruction and help in circuitry design, to Connecticut College for shop facilities and laboratory space, and to my father for statistical analysis. I also appreciate the secretarial help of the North Carolina Department of Mental Health.

Reply to David J. Barker by Allan L. Jacobson

Barker is correct in concluding that by "predominant choice," we meant the alternative chosen 13 or more times on the 25 test trials. We did not intend to suggest anything else, and in fact, we pointed out in the text that "absolute preferences were on the whole small."

As for the statistical test: the approximate number of Ss and the way we would treat the data were decided in advance. We did not expect to obtain strong preferences,

even if our results were positive, since (among other reasons) recipient rats were never rewarded during testing; thus we chose a "sensitive" criterion of preference. Perhaps in so doing, we inadvertently capitalized on the vagaries of χ^2 . If so, Dr. Barker is indeed justified in considering our conclusion too strongly stated. We hope at some future time to resolve this question more satisfactorily in the laboratory.

For Comment on Jacobson et al see page 314.

Shock duration and adhesion in the planaria, *Phagocata gracilis*¹

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Planaria, *Phagocata gracilis*, were assigned to five shock duration conditions. Shocks were continued every 18 sec. until Ss no longer responded by moving freely but adhered firmly to the trough. Trials to adhesion was found to be an inverse function of shock duration; total shock required for adhesion was a direct function of shock duration. The results are discussed in terms of morphological characteristics of planaria.

Electric shock may selectively produce several behavioral effects in planaria depending on the parameters of shock used (Halas, Mulry, & DeBoer, 1962; Barnes & Katzung, 1963). An unconditioned behavioral consequence of repeated noxious stimulation is a reduction in responsiveness and locomotion. Such reduction has some generality as it has been observed when the aversive stimulus was removal of water (Best & Rubenstein, 1962) and shock (Pearl, 1903). The present study investigates the effects of shock duration on locomotion in planaria.

Subjects

The Ss were 40 planaria, *Phagocata gracilis*, 7-11 mm. long, which were originally obtained from a creek located outside the city limits of Bloomington, Indiana. All Ss were selected from a larger colony of *P. gracilis* which was maintained at all times in opaque, milk glass bowls containing aged tap water. Water was changed once a week, immediately after the weekly feeding of beef liver.

Apparatus

The experimental apparatus consisted of a circular, V-shaped, plastic trough 1/2 in. wide, 3/8 in. deep and 24.7 in. in circumference. This trough formed the recessed perimeter of a solid circle which was mounted, at its midpoint, on a plastic base. A graphite and oil lubricant between the two surfaces permitted manual rotation of the trough. Two silver electrodes, mounted on the base and extending into the trough, formed a fixed diameter of 7-7/8 in. A dc shock source supplied 6 volts through the electrodes which was sufficient to reliably elicit a vigorous contraction. Trough and base rested on a large wooden surface painted flat black and were centered between two identical 100 watt light bulbs located 15 in. apart and 6 in. above the trough. Suspended below each light bulb was a heat filter containing 2 in. of water. A variable transformer controlled light intensity which was adjusted to be approximately 5 ft.-c incident light as measured by a Gossen Lunasix light meter. Temperature in the experimental room was maintained at $68^{\circ} \pm 2^{\circ} \text{F}$. Prior to an experimental

period, the trough was filled with aged tap water at room temperature.

Procedure

Each S was assigned to one of five shock duration conditions and tested individually according to a random, predetermined order. A pipette was used to transfer planaria from the colony bowl to the trough. All Ss were free-moving in the trough at the onset of training. Each planarian was individually centered between the electrodes and the relative position of each S in relation to the electrodes was maintained by manual rotation of the trough. When an S turned around in the trough, a switch permitted the polarity of the electrodes to be reversed. Each S received either .5, 1, 2.5, 5 or 10 sec. duration of anodal (Ss head nearer anode), dc shock on each trial. An intertrial interval of 18 sec. was used throughout. Shock trials were continued until S was no longer free-moving and had firmly adhered to the side of the trough for 10 consecutive seconds.

Results

The mean number of trials to adhesion for the five shock duration groups was compared. These results are summarized in Fig. 1. It is apparent that with the longer shock durations, fewer trials were required for an S to stop moving and adhere to the trough. This relationship was confirmed by analysis of variance ($F=20.66$; $df=4/35$; $p<.001$). Further comparisons indicated that shock durations of 2.5, 5 and 10 sec. yielded adhesion in significantly fewer trials than either shock durations of .5 or 1 sec. In addition, adhesion occurred more rapidly when the shock duration

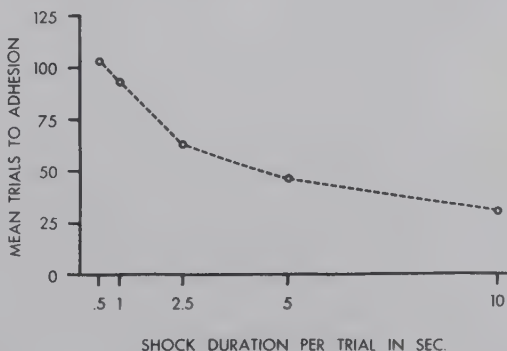


Fig. 1. Mean shock trials required for adhesion for five shock duration conditions.

was 10 sec. than when it was 2.5 sec.

The mean total shock required to yield adhesion for the five shock duration groups was also compared. These results are summarized in Fig. 2. It is apparent that there is a direct relationship between shock duration and total shock required for adhesion. This was confirmed by analysis of variance ($F=26.9$; $df=4/35$; $p<.001$). Further comparisons indicated that shocks of 2.5 sec. duration or longer required a greater total amount of shock than shocks of .5 sec. duration, that shocks of 5 sec. duration or longer required a greater total amount of shock than shocks of 1 sec. duration, and finally, shocks of 10 sec. duration required a greater total amount of shock than shocks of 2.5 sec. duration.

One could argue that the reported effects are due to the fact that Ss receiving 10 sec. of shock on each trial are also spending a greater amount of time per trial in the trough than Ss receiving lesser durations of shock. That an analysis of variance for total time in the trough was highly significant ($F=10.97$; $df=4/35$; $p<.001$) considerably weakens such an argument.

Discussion

The observed effect, i.e., that repeated shock stimulation results in non-locomotion and adhesion to the trough, is consistent with morphological characteristics of *P. gracilis*. Although the family Planariidae, to which *P. gracilis* belongs, is distinguished because they lack adhesive organs (i.e., have neither glandulo-muscular adhesive organs nor a true sucker), members of the

class Turbellaria, including *P. gracilis*, are supplied with glands having adhesive functions (glandulo-epidermal adhesive organs); there are eosinophilous glands which encircle the ventral surface near the margin forming a marginal adhesive zone (Hyman, 1951). It may not be entirely accurate to identify the non-locomotion we have observed as being due exclusively to adhesion; Pearl (1903) reports that dc current quickly paralyzes planaria and non-locomotion in the present study may represent the joint effects of paralysis and adhesion. Regardless, the resultant non-locomotion is an important behavioral change as a number of behaviors (e.g., gliding, crawling, etc.) have been eliminated, thereby limiting the behavioral repertoire of each S.

Our observations indicate that adhesion can occur reasonably rapidly when successive shocks are received and that an S adheres primarily marginally and posteriorly, which permits S to turn right or left but to do little else. This limits the behavioral repertoire of each S by eliminating those competing behaviors which predominated prior to adhesion. In this connection, Jensen (1965) has pointed out some of the inherent difficulties in the use of shock as a US in learning experiments. The results of the present experiment support this and cast doubt upon the continual efficacy of shock as a US in planaria research. The limiting behavioral consequences of shock-induced-adhesion represents a profound behavioral change which must be considered in the interpretation of experiments which use shock in attempting to demonstrate learning in planaria.

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Note

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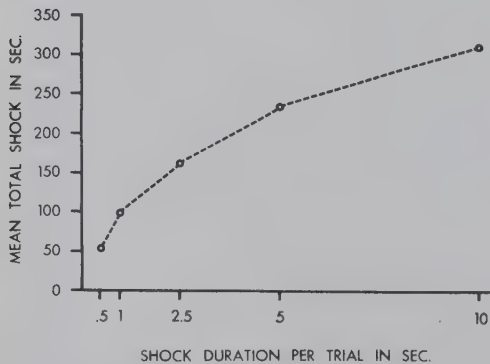


Fig. 2. Mean total shock in sec. required for adhesion for five shock duration conditions.



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The effect of light on sound intensity generalization after two-stimulus discrimination training¹

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This study determined if a sound intensity generalization gradient is displaced laterally if extraneous light intensity is changed from training to test after two-stimulus discrimination training. The results agreed with previous studies on three-stimulus discrimination training in that, (a) when Ss were trained in the absence of a light, introduction of the light on generalization-test trials displaced the generalization gradient toward the weaker sound intensities, and (b) when Ss were trained in the presence of a light, omission of the light on generalization-test trials displaced the gradient toward the larger sound intensities.

It has been shown that a lateral displacement of the generalization gradient occurs if extraneous stimulus intensity or drive level is changed from training to test (Zajonc & Dorfman, 1964; Zajonc & Cross, 1965; Dorfman & Miller, 1965). In these studies, tests for stimulus generalization were performed after three-stimulus discrimination training. It is possible that the displacement of the generalization gradient might be uniquely associated with three-stimulus discrimination training. If the displacement is uniquely associated with such training, then the sensory-interaction hypothesis that Zajonc & Dorfman (1964) proposed for these data would appear premature.

Method

The Ss were 48 girls enrolled in San Diego State College. The sound intensities were generated by a Hewlett-Packard audio-signal generator and delivered to dynamic earphones (Permoflux, PDR-8). Each S was tested individually in a sound-proof room (IAC, Model 400-A). Stimuli were presented automatically and responses were recorded automatically. The center light (C-light) was a sheet of milk glass illuminated by two fluorescent lamps (G.E. 4W daylight) with an ignition voltage of about 250 volts d.c. and had a luminance of 152 ft.-L.

For purposes of comparison, this experiment was identical to that of Dorfman & Miller (1965) except for the discrimination-training. In the experiment by Dorfman & Miller (1965), there was three-stimulus discrimination training, and in this experiment, two-stimulus discrimination training. The Ss were divided into two groups of 24 each. Both groups were given a two discrimination problem (61 db, 71 db re .0002 dyne/cm², 1000 cps) in which they were reinforced for making the response "win" to the sound intensity of 71 db and the response "lose" to the sound intensity of 61 db. Group 1 was trained in the absence of the C-light and Group 2 was given the C-light on all training

trials. When the C-light was presented, it always came on and terminated simultaneously with the sound. The particular procedure was adapted from Brown, Clarke, & Stein (1958) and has been used in studying spatial generalization. Ss were told that they were going to participate in a horse-betting situation in which they were to guess whether a particular horse would win or lose on each race of a series of races. During training, the S was instructed as to whether the horse won or lost the race by flashing a left or right light after the response. Above each light, a sign saying "win" or "lose" was placed. For half the Ss in each group, the left light signified "win" and the right light "lose," with the opposite being the case for the other half of the Ss. The Ss indicated their choice by pressing the left (right) key if they thought the horse would win the race and the right (left) key if they thought the horse would lose the race. If the 71 db tone was presented, the horse always won the race, and if the 61 db tone was given, the horse always lost the race. There were 60 training trials, 30 trials of 61 db and 30 trials of 71 db. After training, they were given four blocks of generalization-test trials. On each generalization-test trial, one of seven sound intensities (61, 62, 64, 66, 67, 69, 71 db) was presented in the presence or absence of the C-light.² No feedback was given on the test trials. Each test block consisted of the random presentation of all the sound intensities under both light conditions (14 trials). There were also four additional training trials in each test block, two trials on 61 db and two trials on 71 db.

The duration of the sound was 1 sec., the interval between onset of sound and onset of reinforcing lamp 3 sec., and the intertrial interval 15 sec.

Results and Discussion

Before considering the results on the generalization tests, it might be noted that Group 1 was more accurate than Group 2 during training as evaluated by analysis of variance, $F=12.68$, $df=1/46$, $p<.001$. In contrast to the results of Dorfman & Miller (1965), these results showed that accuracy was higher in the no C-light condition. At present, there is no explanation for these divergent findings.

Figure 1 shows the post-discrimination generalization gradients under the no C-light and C-light conditions. These results agree with the findings of Dorfman & Miller (1965). In Group 1 (no C-light training), presentation of the C-light displaced the gradient toward the lesser physical intensities, and in Group 2 (C-light training), omission of the C-light displaced the gradient toward the larger physical intensities. In order to

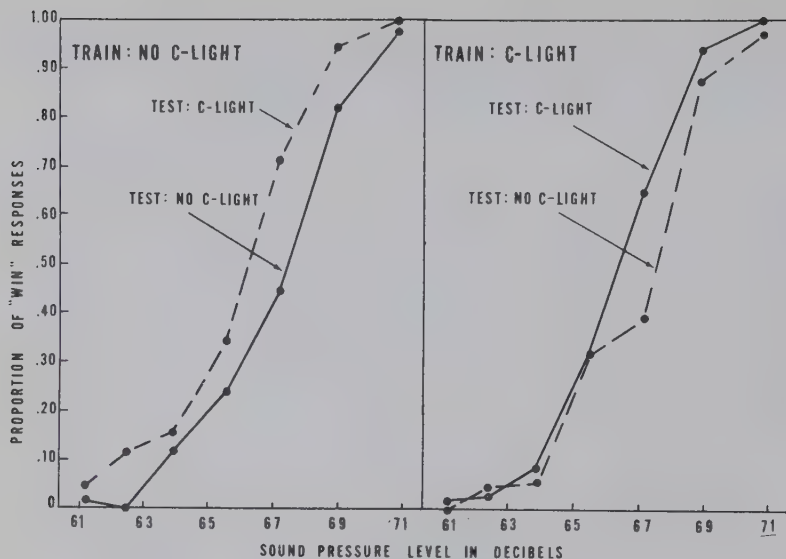


Fig. 1. Proportion of "win" responses as a function of sound pressure level. The solid lines were used to represent the test gradients obtained with the light condition the same in training and test.

evaluate the reliability of the displacement, each S's distribution of responses to the sound intensities was treated as a frequency distribution and the mean of each distribution was computed for the no C-light and C-light gradient on each S. Displacement of the gradient was indicated by a difference in the mean of the gradients under the two conditions. In the analysis of variance, each S had two scores, a mean of the gradient of the no C-light condition and a mean of the C-light condition. Analysis of variance performed on these data revealed a significant Test effect, $F=19.86$, $df=1/46$, $p<.001$, and a significant Training by Test interaction, $F=4.91$, $df=1/46$, $p<.05$. In both groups, the gradient of the C-light test was displaced to the left of the gradient of the no C-light test, with the reliable interaction indicating a larger displacement in Group 1. In addition to differences in the means of the gradients, a displacement of this form would also imply a larger percentage of "win" responses in the C-light test than in the no C-light test. As can be seen, Fig. 1 shows more "win" responses in the C-light test for both Group 1 and 2. Analysis of variance of the arcsine

transformation of the percentage of "win" responses revealed a significantly greater number of "win" responses in the C-light test, $F=29.94$, $df=1/46$, $p<.001$.

In summary, these data show rather clearly that a lateral displacement does occur after two-stimulus discrimination training, and that, therefore, the displacement is not uniquely associated with three-stimulus training.

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Notes

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2. Unequally spaced stimuli should not affect the major results.

Prediction of complex verbal learning¹

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Estes' (1959) linear stimulus sampling model was modified to predict response probability on trial n on the basis of response probability on trial 1. The model was employed to predict three learning functions for a group of Ss learning a poem. Statistical analysis indicated high predictive power. The theoretical functions, based on observation of performance after 5 min. of practice accounted for 99% of the trials variance over 35 min. of performance. The findings are discussed in terms of applied and theoretical considerations.

Mathematical models are at times presented with the implication that they apply to complex verbal learning (Estes, 1964). Actual evidence for such application is scarce, for applications of these models are usually restricted to two-choice situations in which the population of stimuli is constant and all stimuli have an equal probability of being sampled on the first trial. In the present study, a modification of Estes' linear stimulus sampling model (1959) was employed as a predictor of poetry learning.

The linear stimulus sampling model theoretically falls far short of applicability to complex verbal learning. Despite its restrictions, however, it has two advantages over most other models. One of these advantages is that it is simple. In the function

$$p_{n+1} = (1 - \theta)p_n + \theta \quad (1)$$

the probability of a response on trial $n + 1$ is expressed in terms of response probability on trial n , and in terms of θ , a parameter with a value between 0 and 1.

The second advantage is that the model seems rugged enough to stand various violations of its assumptions and yet to retain predictive power. This point is illustrated in its present application.

The linear stimulus sampling model can be simplified further if the assumption is made that the response probability p_0 of a hypothetical trial No. 0 equals 0. From this assumption it would follow that $p_1 = \theta$ and

$$p_n = 1 - (1 - p_1)^n \quad (2)$$

This equation permits prediction of performance on trial n on the basis of p_1 only.

Method

As a part of a larger experiment, 68 students enrolled in an introductory psychology course at the University of Cincinnati were given the task of learning a 64-word selection from E. A. Poe's *Tamerlain*. All Ss were initially unfamiliar with the poem. A test booklet consisting of 25 identical sheets with the poem written on the upper half was provided. On the lower half of each sheet underlined spaces proportional to the lengths of the words comprising the poem were presented. The upper half of each sheet was covered by an opaque overlay

with a space for writing a "time number." During the administration, the experimenter wrote consecutive numbers on the blackboard, starting with 1, and changing them to the next higher integer every 15 sec. The Ss were instructed to read the poem on the first page, then to go on to the next page, record the time number that was presently on the blackboard, write down in the spaces provided as much of the poem as they could remember, flip up the overlay sheet to review their reproduction against the original, then go on to the next page, write down the time number, etc. Ss were self paced. This process was repeated for 37.5 min.

Results

Performance was evaluated in terms of number of correct words in each of seven reproductions, i.e., those on which Ss were working at the end of 5, 10, 15, 20, 25, 30, and 35 min. from the starting time. The trials effect was significant ($F = 350.69$, $df = 6/402$). On the basis of the first trial p_1 was established. A trend analysis was performed, testing the observed data against the trend expressed by the function

$$p_n = 1 - .54^n$$

which was obtained from equation (2) and p_1 . The trend accounted for .991 of the trials' variance (see Fig. 1).

In order to determine whether equation (2) also had predictive power for extreme cases, two groups of 10 Ss each were selected from the original sample. One of these groups consisted of the 10 Ss with highest overall performance; the other was composed of the 10 Ss with lowest overall performance. A separate analysis of variance was performed for each group. The trials effect was significant in each case (high: $F = 88.74$, $df = 6/54$; low: $F = 63.13$, $df = 6/54$). For each group, p_1 was established, and the observed data were tested against the resulting functions, based on equation (2). The trends accounted for .988 and .992 of the trials variances for high and low groups, respectively (see Fig. 2).

Discussion

From the viewpoint of applied psychology, the present findings suggest that the model as described in equation (2) yields an efficient predictor of later performance based on the observation of initial performance only. Performance after 35 min. can be predicted rather accurately after 5 min. (See Fig. 2).

From a theoretical viewpoint the findings are, in some respects, puzzling. Learning a poem is a complex task. It is doubtful that one word represents one stimulus, or that the sampling of one word is independent of the sampling of another word. There is no reason to believe that once a word has been correctly recalled, it will

continue to be correctly recalled on all following trials. (In fact, examination of the reproductions indicates the contrary.) Finally, the assumption that $p_0 = 0$ may be seriously questioned. In summary, all assumptions of the model were violated to a greater or lesser extent, and all that may be said for the application of this model to the present data is that it predicts them well.

Inspection of Fig. 1 reveals that the deviations of the data points from the function, even though they are small, are systematic. If p_0 is assumed to be .057 rather than 0, the resulting function describes the data better. This procedure, however, entails determining an additional parameter, p_0 , which obviates performance prediction on the basis of p_1 only.

While the present research may be taken to support Estes' linear stimulus sampling model, and while an efficient performance predictor has been suggested, it is also patently evident (Fig. 1) that the model, particularly as interpreted in equation (2), is not the

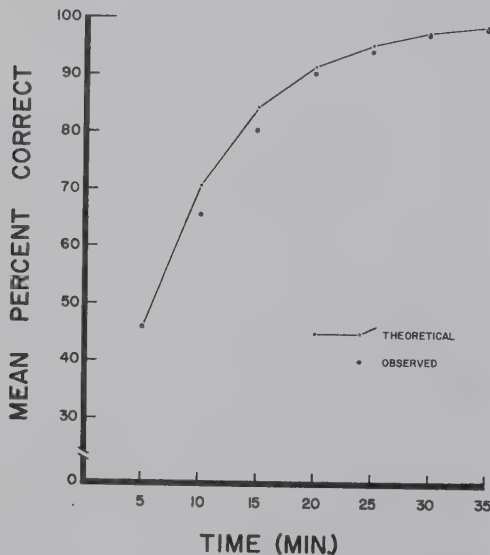


Fig. 1. Percent correct responses, observed and theoretical, as a function of time: group mean function. ($N = 68$).

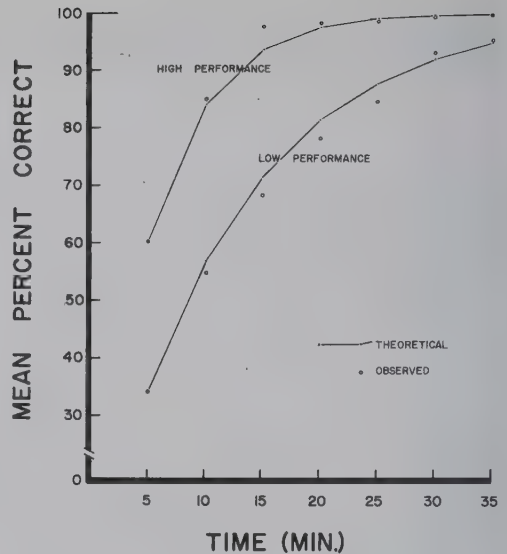


Fig. 2. Percent correct responses, observed and theoretical, as a function of time: extreme subgroup mean functions. ($N_{\text{high}} = 10$; $N_{\text{low}} = 10$).

best possible predictor of complex verbal learning. Until further research is done, however, it seems to be one of the better existing predictors, if only by virtue of the fact that others apparently have not been employed with more success. Finally, the present research indicates that prediction of complex verbal learning does not lie beyond the scope of existing mathematical models.

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Note

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Associative symmetry with two conditions of perceptual organization

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College Ss were run on a paired-associate task using colors and numerals embedded in "good-fitting" and "poor-fitting" geometric figures. Symmetry of association was demonstrated, but there was no effect of fittingness upon either forward or backward associations.

Traditionally, paired-associate tasks have utilized relatively complex verbal materials. In an attempt to forestall verbal mediation, complicated lists of nonsense syllables have been evolved. However, Ss have been able to overcome E's purpose in employing nonsense syllables by using their own verbal mediators as suggested by Asch & Ebenholtz (1962) and McNulty (1966) among others. A second approach to this problem is the use of material with high meaningfulness, familiarity and availability (Horowitz, Norman, & Day, 1966). Such materials would include numerals and color sensations as well as common words. The recognition of color sensations and their codability are highly related (Brown & Lenneberg, 1954), and thus the easily codable colors (e.g., red, green) should not serve as less available stimuli than their names.

In their review of availability and associative symmetry, Horowitz, Norman, & Day (1966) have cited several authors who suggest that, under conditions of high availability, forward and backward associations in a paired-associate task should be equally strong. Since numerals and color sensations are highly available stimuli, it is expected that stimulus-response pairs of these materials should elicit symmetrical associations, regardless of which type of material provided the stimuli and responses.

The purpose of the present experiment was to test the preceding hypothesis under two conditions of perceptual organization. Köhler (1941) states, "figures which fit one another in that they give a regular pair should yield better associations than others which constitute less fitting pairs" (p. 502). Fittingness was defined here as the "fitting together" of a triangle into a notched rectangle to give a completed figure (see Fig. 1). Triangles with their apexes away from the notch constitute non-fitting figures. The stimuli and responses were embedded in the geometric figures.

Since perceptual organization was expected to take place automatically and at a primitive level (precognitively), Ss were not instructed as to the differences in the organization of the material. A one-trial learning paradigm was utilized to minimize the vitiation of the purely perceptual aspects of the task by the intrusion of cognitive factors.

Method

Subjects. Ss were 159 college sophomores from the introductory Psychology classes at Trenton State College, run in groups of 3-8.

Apparatus. Stimuli were rear-projected on a translucent screen 40 in. square, placed 3 ft. from the lens of a Kodak Carousel Model 550 projector. The automatic actuating system of this projector was pulsed at 1.5 sec. intervals by an electronic timer. Colors were obtained by exposing common construction paper through a white frame.

Stimulus materials. Figure 1 shows the various combinations of stimulus slides. Each slide contained a number (4, 5, 6, or 7) and a color patch (red, blue, yellow, or green). In addition, the apex of the black triangle containing the white number pointed toward (Toward) or away from (Away) the notch in the rectangular color patch. There were 14 conditions in all: seven pairings with the number followed by the color, the same seven pairings with the color followed by the number. Each number and color were paired on each list—four slides per condition. The order of the slides was randomized for each list with the restriction that each list contain two Toward and two Away slides.

Procedure. Ss were seated in two rows 4 to 8 ft. in front of the screen in a darkened room. All Ss could easily see the screen. They were instructed that they would see a "ready" slide followed by four slides,

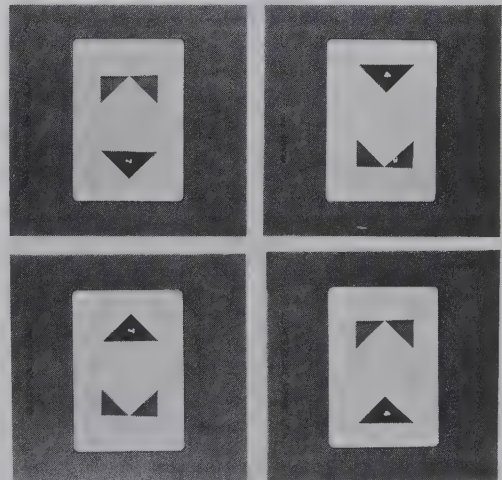


Fig. 1. Examples of Toward and Away slides of number-color and color-number configurations.

each with a number and color on it, and that their task was to learn to associate each number and color. They were also warned that the slides would appear in rather rapid succession.

Each slide was presented for 1.5 sec., followed by a 1.5 sec. interstimulus interval. Following the one-trial presentation of the paired associate task, Ss were given an interpolated task. They were instructed to write, in 3 min., all the words that they could think of beginning with the letter S and ending with the letter L. When the interpolated task was completed, half the Ss were given mimeographed sheets containing the left-hand member and instructions to supply the right-hand member; remaining Ss were given sheets containing the right-hand member and instructions to supply the left-hand member. All response sheets followed one of two formats; they included either the numbers in serial order or the colors in spectral order.

Results

That one trial was sufficient to produce learning in this task is demonstrated by the fact that recall was above chance expectancy. The mean number of correct responses for all Ss combined was 2.2. As expected, there were more correct responses to the first item of the list than to the other items ($X^2=10.48$, $df=3$, $p<.02$).

Forward-backward symmetry was demonstrated by the finding of approximately the same number of errors forward and backward. This held regardless of whether the stimulus pairs were number-color or color-number. There were no preferences for any number or color.

Overall, there were no significant differences in errors for the Toward vs. Away items. However, there were fewer Toward errors for the color-number Ss on the first item ($X^2=7.16$, $p<.01$) while these Ss made more Toward errors on the third item ($X^2=4.70$, $p<.05$). Considering the number of comparisons made, these results may be due to chance.

Discussion

Simple stimulus materials lead to efficient learning in one trial, even with a relatively brief exposure time and an interpolated task preceding recall. The general availability of this simple material undoubtedly assists S in his recall without his having to use private mediators. Symmetrical associations also seemed to be assisted by the general availability of this material.

Our second order hypothesis, derived from Köhler, that fitting figures should produce superior associations of the embedded material was not confirmed. This is perhaps due to the ascendancy of the availability of the materials or to the relatively brief exposure time. If the task had been more difficult, Ss might have taken advantage of this additional cue. It might be argued that in order to be used as an aid, perceptually organized entities must be exposed for a long enough time for cognition to take place. Instructions to the S about the fittingness-nonfittingness dimension might produce better recall of the fitting figures in a more difficult task.

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Note

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Similarity among the implicit stimuli and responses in mediated paired-associate learning

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In an A-B, B-C, A-C mediation paradigm similarity among the Bs was varied over four conditions. The effect on paired-associate performance in the A-C stage was as predicted from studies concerned with the effect of intralist similarity in conventional paired-associate learning. Performance facilitation in the A-C stage decreased as the similarity of the Bs increased.

In a theoretical and review article by Jenkins (1963) the suggestion was advanced that the next phase of research on mediation should be an experimental analysis of the conditions of mediation. One approach to the investigation of the conditions of mediation in paired-associate learning would be to compare the effects of variables on overt performance in conventional paired-associate tasks with the effects of the same variables on the implicit performance thought to be involved in mediation. If the implicit stimuli and responses of, for example, the chaining mediation paradigm are to be treated theoretically the same as explicit stimuli and responses, then it might be very helpful to have data directly concerned with the extent of this functional equivalence.

The present experiment was concerned with the effect of intralist similarity among the Bs in an A-B, B-C, A-C chaining paradigm. The theoretical explanation of performance facilitation in the A-C stage is that an implicit response, r_B , with implicit stimulus concomitants, s_B , is mediating the effects of practice in the A-B and B-C stages. The effect of formal similarity among stimuli and responses in conventional paired-associate studies (Levitt & Goss, 1961; Underwood, 1953) would lead one to expect a decrease in the extent of A-C facilitation as similarity of the Bs in the A-B and B-C stages increases.

Method

The experiment employed an A-B, B-C, A-C paradigm in which the As and Cs were consonant-vowel-consonant syllables with meaningfulness values of 47-53 (Glaze, 1928). Intralist letter duplication was minimized. The Bs were pure tones distributed along the mel scale (Stevens & Volkman, 1940), a scale of pitch. Six mel values, 500, 550, 600, 650, 700, 800, were used. The corresponding frequency values of 400, 438, 480, 528, 577, and 693 cps were estimated by linear interpolation from a function relating mels and log frequency (Stevens & Volkman, 1940). All of the tones were presented at 60 db sensation level.

The mediation and control conditions were varied within Ss. In the A-B and B-C stages of the experiment

tones were paired with four of the syllables of the eight item list. The pairing of the syllables and tones was such that the A-C stage performance would be facilitated if mediation occurred. A tone of a specific mel value paired with a given A in the A-B stage was paired with the "appropriate" C in the B-C stage. The appropriate C was the one paired with A in the A-C stage. The difference among the tones was varied over three groups of 20 Ss each. In one group the tone difference was 100 mels; values of 500, 600, 700, and 800 were used. In another group the difference was 50 mels; values of 550, 600, 650, and 700 were used. In a third group there was no difference among the tones. A tone at one of the mel values was paired with each of the four syllables for a given S. The six mel values were used an approximately equal number of times over the 20 Ss. A fourth group was given the tones of 100 mel difference, but the pairing was such that performance in the A-C stage would be inhibited if mediation occurred. The syllables and tones were systematically mismatched from the A-B to the B-C stages. The set of four syllables which were paired with tones was varied within pairs of Ss such that all eight syllables were equally often tone-paired over the 20 Ss within a group.

In the A-B stage Ss were told that some of the syllables would be followed by a tone and that they were to try to learn the correct tone for a given syllable. The syllables were projected on a screen for 5 sec. For the appropriate syllables, the latter 2 sec. of the presentation period was accompanied by the tone. The Ss were instructed to spell each syllable as it appeared on the screen. In the B-C stage Ss were told that some of the syllables would be preceded by tones and that they were to learn the correct pairing. On appropriate items the tone came on for 2 sec. and was followed immediately by a 3-sec. presentation of the syllable. The Ss were instructed to spell each syllable as it appeared on the screen. In both phases 10 trials were given and three different orders of the list were used. The A-C stage consisted of 12 trials of paired-associate learning by the anticipation method with a 2.5:2.5-sec. rate of presentation. Three different orders of the list were used.

The slides were presented by a Kodak Carousel slide projector. The tones were produced by an Echo audio oscillator and delivered to the Ss through a headset. Presentation times of syllables and tones were controlled by two Hunter electronic timers. Ss were randomly assigned to groups from a pool of 80 introductory psychology students who participated in the experiment as part of the course requirement.

Results and Discussion

Six scores were calculated for each S by tabulating the number of correct responses for each block of four trials for the set of syllables paired with tone (Paired) and the set not paired with tone (Unpaired). A three-way analysis of variance was performed on these scores with the four groups as the between-Ss variable and trial blocks and Paired-Unpaired as within-Ss variables. Two of the significant effects of the analysis were trial blocks ($F=391.68$, $df=2/152$, $p<.01$) and the interaction term for trial blocks and Paired-Unpaired ($F=7.92$, $df=2/152$, $p<.01$). The form of the interaction was that the increase in performance from the first trial block to the second was somewhat greater for the Unpaired condition than for the Paired. The absolute differences were not large. Average performance in the Paired condition went from 6.54 correct responses on the first trial block to 10.14 on the second; corresponding values for the Unpaired condition were 5.70 and 10.65.

Major interest was focused on the interaction of groups with Paired-Unpaired since the experimental hypothesis predicted that the difference between performance on the Paired set of syllables and the Unpaired set should decrease as the difference between the tones decreases. It was further expected that an actual reversal in performance on the Paired and Unpaired sets would occur with the group for which the tones were mismatched. The interaction effect for groups by Paired-Unpaired was significant at the .01 level ($F=4.30$, $df=3/76$). Since the three-way interaction was statistically nonsignificant ($F=1.64$, $df=6/152$, $p>.05$), the data was collapsed over trial blocks. A plot of the average number of correct responses in 12 trials by groups and Paired-Unpaired appears in Fig. 1. The pattern of the means in Fig. 1 is clearly in line with expectations from the experimental hypothesis.

The upward trend of the means in the Unpaired condition from the 50 mel tone-difference condition to the Mismatch condition suggests the operation of a set factor which may be peculiar to experiments in which the mediation and control conditions are within-Ss. It

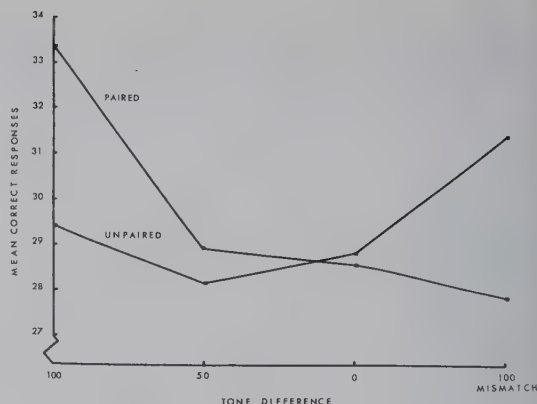


Fig. 1. Mean number of correct responses as a function of tone-difference and whether the syllables were paired or not paired with the tone.

may be that Ss tended to concentrate on Unpaired items when mediation led to incorrect responding.

The results have established that there is a certain degree of functional equivalence between explicit stimuli and responses in paired-associate learning and their implicit counterparts in mediation. Further research directed at an assessment of the extent of such functional equivalence appears useful to the development of mediation theory.

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R-S learning in brain damaged and control subjects

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Brain damaged Ss displayed less symmetry in paired-associate learning than control Ss as measured by both absolute and relative R-S recall. This decrease in symmetry was apparent whether or not a marked deficiency in S-R learning was simultaneously present.

Ekstrand (1966) noted "that the difference between forward and backward associative learning has been drastically overestimated and that if symmetry is not the rule, asymmetry will be very small (p. 60)." Near symmetry of forward (S-R) and backward (R-S) learning is especially apparent when both S and R paired-associate components are meaningful words and differential availability of S and R components (cf. Ekstrand, 1966) is largely eliminated. For example, R-S learning (as measured by recall) averaged 87.7% of S-R learning in a study by Dron & Boe (1964) with college students as Ss and 85.1% in a study by Kausler & Lair (1965) with noncollege adults as Ss.

Ekstrand (1966) also stressed the importance of investigating the conditions under which symmetry breaks down. Contemporary research has investigated primarily task and practice variables as parameters of symmetry. However, another important direction rests in investigating symmetry as a function of S variables. One such variable is the level of functioning of the central nervous system. Kausler & Lair (1965) found that elderly Ss displayed significantly less R-S learning, in terms of both absolute and relative (to S-R learning) amounts, than younger Ss, even though the two groups did not differ in S-R learning. Viewing learning deficiencies in old age as reflecting brain deterioration (e.g., Inglis, 1957, 1959) and generalizing from the Kausler and Lair findings, the possibility exists that symmetry is a learning phenomenon which diminishes whenever brain deterioration is present. The present study tested this hypothesis by contrasting the R-S performance of brain damaged and control Ss.

Method

The brain damaged group (Group B, N=18) consisted of 9 focalized and 9 generalized patients, as determined by neurological diagnosis (mean age=42.4 years; mean years of formal education=10.0 years). Diagnostic classification included cerebral hemorrhage, CBS due to alcoholism, tumor, Huntington's chorea, and encephalitis. In order to minimize motivational deficit resulting from long term hospitalization patients hospitalized for more than 3 years were excluded from this study. The control group (Group C, N=18) consisted of general medical patients in a medical school hospital who were without a history of alcoholism and neurological or psychiatric disorder (mean age = 39.0 years; mean

education=11.6 years). A t-test revealed that the two groups did not differ significantly in age or educational level.

The paired-associate list, identical to that of Kausler & Lair (1965), contained 10 pairs of unrelated words selected from the Minnesota norms. Following practice on a two pair warm-up list, the pairs were presented by means of 3 x 5 index cards at a 4:4 sec. rate (anticipation method) for 15 trials or to a criterion of one perfect trial, whichever came first. Three different serial orders were employed. At the end of S-R practice Ss were given one R-S recall trial at a self-paced rate. On this trial the R words were presented one at a time (via index cards) in a random order, and S was requested to recall the associated S word.

Results and Discussion

Every S in Group C learned the S-R list to criterion within 15 trials (mean number of trials=6.89; SD=2.49). Eight of the 9 focalized patients but none of the generalized patients learned the list to criterion (mean and SD for the focalized patients=11.89 and 3.66, respectively). The maximum number of S-R pairs anticipated correctly on any single trial was determined for each S. This score provided a baseline for computing S's relative R-S score. Group C, of course, averaged 10 correct S-R pairs without variability; Group B had a mean of 7.50 and SD of 2.79. Although the difference between group means was statistically significant ($t=3.85$, $df=34$, $p<.01$), this difference was attributable solely to the generalized patients whose mean and SD were 5.11 and 2.03, respectively. The corresponding statistics for the focalized patients were 9.89 and 0.28. Thus only the generalized patients were markedly below the control Ss in terms of level of S-R mastery.

For absolute R-S recall the mean and SD were 8.83 and 1.44 and 5.44 and 2.63 for Group C and Group B, respectively, a difference in means that was statistically significant ($t=4.84$, $df=34$, $p<.01$). In view of the disparity in S-R learning between the focalized and generalized patients a separate R-S analysis was made for these two subgroups. The mean R-S score was 7.22 for the focalized and 3.67 for the generalized patients. Both of these means were significantly less than the mean for Group C ($t=2.37$, $df=25$, $p<.05$ and $t=6.79$, $df=25$, $p<.01$). In terms of relative R-S scores (the ratio of R-S recall to the maximum number of S-R pairs correctly anticipated on a single trial) Group C averaged 88.3% and Group B 72.5%, a difference that was statistically significant (median test, $\chi^2=11.26$, $df=1$, $p<.001$). Moreover, the depression of relative R-S scores in Group B was independent of classification—the focalized patients averaged 73.0% and the generalized

71.8%. Thus brain damaged Ss displayed less symmetry than controls whether or not their S-R performance differed markedly from control S-R performance.

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A note on the relation between the optic disc and the blind spot¹

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The optic disc is sometimes said incorrectly to lie in a position below the fovea. This misconception arises from neglecting the inversion of the retinal image. The blind spot, regarded as a position in the visual field, in fact lies below the point of fixation, but the anatomical counterpart of the blind spot, the optic disc, lies above the fovea. It is suggested that the term optic disc be used anatomically and the term blind spot be used only to refer to an area in the visual field.

Wyburn (1964) and Neff (1936), describing Stern's work (1926), refer to the finding that the conditions for creating apparent movement result in an impression of movement across the area of the blind spot (BS). While exploring procedures for corroborating such a finding, the author discovered a basic discrepancy in his conception of the relationship of the BS in the visual field to its corresponding anatomical structure, the optic disc, i.e., the area of exit of the optic nerve, in the retina. Indeed, the same misconception appears in certain texts widely used in psychology, viz., Geldard (1953), Andreas (1960), and Kendler (1963). Consequently, it appears appropriate to point out the misconception to others who might share such a notion and who might be in a position to propagate the error.

Geldard in describing the features of the gross anatomy of the eye states that, "The other area to be noted in addition to the fovea centralis is the colliculus or optic disc, situated about 3 mm to the nasal side and 1 mm below the fovea" (1953, p. 23). Andreas is in agreement with Geldard regarding the location of the optic disc when he states that, "The blind spot actually falls slightly below the horizontal retinal meridian" (1960, p. 235). Finally, Kendler makes the statement that, "Slightly below the fovea and to the nasal side of it is the blind spot" (1963, p. 117).

However, in mapping the visual field, on a plane perpendicular to the line of sight, the BS is accurately described as being located slightly below the horizontal meridian, about 1.5° or more (Scott, 1957). Due to the inversion of light waves as they pass through the lens and other media and are registered on the retina, it is apparent that the optic disc, which is the anatomical "reason" for the BS in the visual field, would have to be situated above the horizontal meridian of the eye. In fact, a number of references actually so locate the optic disc. For example, Scott states that,

The position of the blind spot, somewhat below the horizontal meridian of the visual field, corresponds to a position of the optic disc slightly

above—not below as sometimes stated—the horizontal meridian of the eye. It is legitimate to infer that the position of the optic disc, when the eye is in use, is above the horizontal meridian. This is its physiological position and it may be presumed that its anatomical position is nearly the same (Scott, 1957, p. 302).

Another reference by Reed (1960) presents a diagram of the right fundus and the right visual field which clearly locates the optic disc above the horizontal meridian of the eye and the BS below the horizontal meridian of the right visual field. Gray's classic book (1959, p. 1108) diagrams the interior of the posterior half of the left eye, revealing the optic disc clearly above the macula lutea which, of course, contains the fovea centralis. Finally, Southall states that, "The centres of the papilla [of the optic nerve] and the macula lutea are about 4 mm apart, but the latter is a little lower down on the fundus so that its upper border is nearly on a level with the centre of the former" (1937, p. 22).

In addition to these textual references it is possible to demonstrate quite simply that the optic disc must be located above the horizontal meridian of the eye, i.e., above the fovea. One can employ a variation of the usual device found in many introductory psychology texts for demonstrating the lack of sensory receptors due to the existence of the optic disc in the eye. If a vertical row of dots is located to the right of a target on which the right eye fixates and the figure is adjusted for distance to demonstrate the blind spot in the visual field, it will be observed that the lower half of the vertical row of dots disappears, an experience which could only occur if the optic disc were located above the fovea.²

In addition, the many charts of the visual field found in texts on perimetry as well as other references on the eye portray the BS as obviously below the horizontal meridian of the visual field, thus requiring that the optic disc be above the horizontal meridian of the fundus due to the inversion of the lens.

A possible explanation for this misconception might be found in diagrams of the eye presented in various texts. The usual diagram presents a horizontal section of the eye, frequently with the nasal side at the bottom of the figure. Since the optic nerve is located on the nasal side, it is drawn below the fovea centralis in the diagram. However, it may happen that the view of the eye is assumed by the reader to be a sagittal one and that consequently the optic disc is seen to fall below

the fovea centralis. Such an assumption is consistent with a sagittal perspective of the eye. A further confounding factor might be the ambiguity of the terms, optic disc and blind spot. In some references in texts and in oral communications the terms are used interchangeably to refer to an area in the retina. For example, if an author is attempting to convey the location of an area on the retina and uses the term blind spot, his readers may be misled if they interpret the term to refer to an area in the visual field. Kendler (1963, p. 117), Andreas (1960, p. 235) and Gray (1959, p. 1109) have actually so used the term.

Finally, it might be well to conclude this note by suggesting some practices which might help to avoid misconceptions of the relation between the optic disc and the BS. Diagrams of the eye presented in texts should be clearly labelled as horizontal views. In addition, a second diagram presenting a sagittal view of the eye would help to clarify the relationships between the anatomical sites of the optic disc and the fovea centralis. The exposition of relations between the optic disc and the BS would be less ambiguous if authors were to agree on the technical meanings attaching to certain terms, e.g., one convention might be to use the term, optic disc, only in referring to an anatomical area in the retina and the term, blind spot, only in referring to an area in the visual field.

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Notes

1. The author was involved in an NSF Summer Research Program for College Teachers at the University of Michigan, Ann Arbor in the summer of 1965 during which time he came upon the "discovery" described in this note. The author would like to express his gratitude to D. J. Weintraub, Director of the program for his patient guidance and help.
2. The author is indebted to D. Krantz of the Department of Psychology, the University of Michigan, Ann Arbor for this simple and convincing demonstration.

Conditioning effects on two apparatuses'

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Nineteen 6 and 7 year old boys were conditioned on two apparatuses (marble box and gun). Social reinforcement was given by a 20 year old woman. Significant preference change ($p = .05$) was produced on both tasks; however, the correlation between the Ss' conditioning scores on the task was $-.09$.

Social responsiveness has become a popular concept in the study of personality development. Numerous studies have been carried out using change in preference or rate on a motor task after some type of social reinforcement as an indicator of social responsiveness (Gewirtz & Baer, 1958; Patterson & Anderson, 1964; Horowitz, 1962; Levine & Simmons, 1962). The generalizations made from the data provided by the above studies pre-suppose that measures of change in response strength are equivalent, independent of the type of instrumental conditioning apparatus. If there is such a variable as generalized social responsiveness then there should be a high positive correlation between conditioning scores on different apparatuses.

Method

The Ss were 19 6 and 7 year old boys. The reinforcing agent was a 20 year old woman.

Apparatus I was a marble box, adapted from Gewirtz & Baer (1958), which had two holes at the top and was 8 in. high and 8 by 10 in. wide. The two holes were 3/4 in. in diameter and placed 1 in. apart. In a tray at the base of the box were 20 blue glass marbles. The box was located on a level platform adjusted so that the base was approximately waist level for S. Apparatus II consisted of a gun which S fired at a target projected on a screen approximately 5 ft. in front of S. The gun was mounted on a stand which also contained the projector that projected the target slide onto the screen. The gun projected a light-ray with which S aimed. When he pulled the trigger, a buzzer sounded and side preference was recorded on an Angus Esterline Tape. A 22 ft. "rehabilitated school bus" served as a laboratory and was taken to the school.

S was brought into the mobile laboratory, and told to sit on the seat behind the gun. He was given the following instructions: "This is a game we want you to play. You are to shoot this gun at the pictures of animals which will appear on the screen. There will be two animals in each picture, but you are to shoot only one and take only one shot per picture. You can shoot either animal. After you have shot, return the light ray to the center of the picture. Take your shot quickly, as soon as the pictures come on the screen. Keep shooting as long as the pictures come on the screen

or until I tell you to stop. Sit back, relax and aim with the light ray. Do you understand? You can start shooting as soon as a picture comes on the screen."

S was given 40 shots for the base operant period. Then the reinforcing agent, who sat on the bench beside him, gave him 20 reinforcements on the least preferred side (determined during the base operant period) and 10 reinforcements on a variable 4:11 schedule. The reinforcing agent was given a signal through a microphone on the appropriate trials. The reinforcements consisted of the following words: Good, Fine, Good Shot, Got Him, and Very Good.

The next task was the marble box. The S was told to stand behind the box and was given these instructions: "This is the other game we told you about. What I want you to do is drop the marbles into these holes. Pick up just one marble at a time and drop it into either one of the holes. You may use either hand but only one hand at a time (demonstrates). Now you do it. (Subject drops a few marbles for practice). That's all there is to it. Remember, either hand, either hole; but just one marble at a time; and keep dropping marbles until I tell you to stop. Okay, begin."

A 100 trial base operant period was given, then 20 1:1 and 10 4:11 reinforcements were given on the non-preferred side. The reinforcements consisted of: Good, Fine, Very Good, Okay, and Great.

The measure of preference change on both the gun and marble box was obtained by computing the proportion of responses on the non-preferred side every 20 sec. and computing the median proportion for the base operant period and the experimental period. The difference score for each individual on both apparatuses was converted to a T Score (Patterson & Hinsey, 1964).

Results

Both apparatuses produced significant change ($p = .05$) in the preference behaviors of S. However, the correlation between the two difference scores was $-.09$. The prediction that the gun and marble box would be highly correlated was disconfirmed.

Discussion

The finding that social responsiveness is not independent of type of apparatus is disappointing. Patterson & Hinsey (1964) found a .75 correlation on test-retest using the marble box, suggesting that the conditioning by social reinforcers can be stable when all parameters are held constant. The effects of apparatus, reinforcing agent, and schedules of reinforcement should be better understood before further theorizing and experimentation are done with social responsiveness (defined by conditioning scores).

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Note

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Erratum

Rieber, M. Response alternation in children under different schedules of reinforcement. *Psychon. Sci.*, 1966, 4 (4), 149-150.—On page 149, second column, second paragraph, beginning with the sixth line, the text should read: "The second group (50%A) was rewarded on every other trial. On rewarded trials M & M's were placed under both blocks. The third group (50%R) received . . ."

Information search as a function of conceptual and environmental complexity¹

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Individuals operating at complex and at simple levels of conceptual structure played a tactical game for three ½-hr. periods. There was a negative relationship between information input and subsequent information search. Conceptually simple Ss, while generally requesting more information, wanted feedback about ongoing events; complex Ss requested information about new aspects of the game.

In a recent study (Streufert, Suedfeld, & Driver, 1965a), it was demonstrated that active information search in a game situation differed as a function of information load (rate of information input) and of the conceptual complexity of the Ss composing the group. During playing periods where information input load was high, Ss requested further information less frequently than during low-load periods. While there was no overall difference in information search between groups of Ss differing in conceptual structure (as defined and described in Schroder, Driver, & Streufert, in press), a significant interaction effect was found: groups composed of conceptually simple Ss were more influenced by the environment than were complex groups, in that the former showed much more information search under low load and much less under high load. Complex groups maintained a relatively stable level of search in all conditions.

The study reported here is a partial replication of Streufert et al (1965a) using individual players rather than groups; three load conditions instead of seven; and 1-1/2 hr. of game time as contrasted to approximately 5 hr. Besides wanting to see whether a more economical experimental procedure would yield consonant results, we were also interested in whether the tactical game which had previously been used only with groups of Ss (Streufert, Clardy, Driver, Karlins, Schroder, & Suedfeld, 1965b) would be appropriate for use with single Ss. Last, we wished to investigate not only the amount but also the kind of information which Ss requested: the theory of Schroder et al (in press) predicts, but our previous study did not test, that simple Ss would be preoccupied with 'monitoring' information (keeping track of past and ongoing events) while complex Ss would be more interested in new plans and potentialities.

Subjects

Eighteen male and 18 female undergraduates, enrolled in an introductory psychology course, were used as Ss. Half of them had been identified as conceptually complex and half as simple by the same technique as was used in the previous study, the Sentence Completion Test (Schroder & Streufert, 1962).

Procedure

Each S spent 90 min. playing the tactical game used in Streufert et al (1965a) and other previous experiments, and described in Streufert et al (1965b). Briefly, each S commanded a simulated combined-arms (land, sea, and air) force and directed the force in the invasion of an island. He made his moves by transmitting written orders to E, who from time to time sent him written messages concerning the progress of the game. Messages were exchanged through a wall chute. In the present study, the session was divided into three 30-min. periods. During the first (warm-up) period, each S received 10 messages. During the second (critical) period, three levels of input load were used, with six complex and six simple Ss randomly assigned to each level:

High: 30 messages
Moderate: 10 messages
Low: 2 messages

During the third (test) period, information was provided only in response to a specific information request by S. Of course, Ss were not told the duration of the session, the division into periods, nor the information input pattern; at no time was there any restriction on the number of orders S could originate.

Each order form handed in by S included only one order. Forms were categorized as either information search orders (initiating a reconnaissance action or requesting a progress report) or tactical orders (initiating or continuing an actual operation—landing, attack, defense, etc.—in the game).

Results and Discussion

Analysis of variance for the proportion of information search moves to total orders during the test period showed both main effects to be significant (for information load during the critical period, $F = 20.54$, $p < .001$; for conceptual structure, $F = 5.56$, $p < .05$). The proportion of information search orders decreased as load increased; and, except in the high load condition, simple Ss requested more information than complex Ss. Conceptual structure differences were significant ($p < .05$) in the low and the moderate load conditions, but not in the high load condition (critical difference = 10.66; differences were 13.83, 10.67, and 3.17, respectively).

A further analysis was performed to indicate the relative proportion of novel situations investigated by Ss during the test period. Information requests were scored according to whether they referred to an ongoing event ("How is the attack at X progressing?") or to a situation or location where S had not been engaged previously

("Send intelligence agents to report on enemy strength at Y"). The proportion of "novel" to total information requests was significantly higher for complex than for simple Ss ($X^2=4.24$, $p < .05$).

The negative relationship between information input and subsequent information search replicated the findings of Streufert et al (1965a). The fact that simple Ss performed more information search in the low and moderate conditions was in accordance with the theory (Schroder et al, in press), because such Ss are thought to use information in a more temporally isolated fashion (see also Streufert & Schroder, 1965). Since the individual bases only one or a few responses on each piece of information, he needs more information to maintain effective play than does the complex person who can use each item, in combination with other items, as the basis for many moves. Reversal under high load may indicate that in this situation the simple S has sufficient stimuli upon which to base his moves, while the complex person may still need information to develop his integrative strategy. Thus, the needs of the simple S are satisfied by large amounts of information per se, whereas the complex S needs specific items of information regardless of total load. This hypothesis should be tested in the future by independently varying strategy-relevance and load.

Simple individuals were more interested in receiving feedback about ongoing activities, while complex Ss

searched new, hitherto unexplored aspects of the situation. This difference in orientation had been expected on the basis of the theory, and lends further confirmation to the general approach to the study of information motivation which has been developed by Schroder et al (in press).

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Note

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The effect of signal intensity on comparative judgments of auditory durations¹

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Human Ss made comparative judgments of the duration of two tones in a forced-choice situation. Pairs of tones with either the same or different intensities were presented with durations from 0.5 to 1.6 sec. Comparisons were more accurate when the two tones were of the same intensity than when they were of different intensities, and were most accurate when the tones were of higher intensities. The results are compared with previous findings relating comparative judgments of duration to sensory modality.

In a recent study Tanner et al (1965) investigated comparative judgments of signal duration by varying the modality to which the signals were presented. It was found that in a two-alternative forced-choice situation, human Ss were more accurate with intra-auditory comparisons than with either intravisual or intramodal comparisons. Evidence was presented that there was a bias toward judging visual signals to be longer in duration than auditory signals.

The purpose of the study reported here was to determine whether intensity differences between two signals might affect judgments of signal duration in a way comparable to that which has been shown with differences in modality. If the effects of modality and intensity are found to be comparable, the construction of a model of the psychophysics of signal duration should be simplified.

Previous investigations of the effect of intensity on the accuracy of judging auditory durations have yielded conflicting results. Creelman (1962) has discussed several of these studies. His own research supports the hypothesis that intensity is important only to the extent that it contributes to the clear detection of the signal throughout its presentation period.

In the present study Ss made comparative judgments not only of the duration of two tones with the same intensities, as did Creelman's Ss, but also of two tones with different intensities. The latter were included, in part, to determine whether or not a bias existed toward calling either the more or the less intense tone longer.

Method

The procedure was similar to that of the previous study by Tanner et al. The Ss were 11 male college students, all of whom were free from gross auditory impairment as determined by an informal interview. None of the Ss had performed the task previously. S sat in a dimly lighted, sound attenuated room. The auditory signals, 1000 cps sinusoids, were presented through earphones (Permoflux, D4S-17) at an intensity of either 86 or 106 db, both re 0.002 dyne per cm². To insure that the "on-times" of the signals did not depend on intensity, the rise and fall were gated instantaneously; therefore audible clicks accompanied the gating. White noise (100 K cps, low pass) at 56 db also was presented through the earphones.

Each S performed for a total of 6144 trials, grouped as 12 sessions of 512 trials each. On each trial S's task was to judge which of two successively presented tones was longer by pressing one of two response switches. Three pairings of signal durations were used in the study: 0.5 sec. vs. 0.6 sec., 1.0 sec. vs. 1.1 sec., and 1.5 sec. vs. 1.6 sec. Thus the difference in duration of the signals in each of the three pairings (Δt) was 0.1 sec. As the durations became longer, the relative difference between the incremental duration and that of the briefer signal ($\Delta t/t$) became smaller. Hereafter the three pairings of signal durations will be designated as D(0.5), D(1.0), and D(1.5), the numeral denoting the duration of the briefer signal of a given pair. Only one of the three pairings was presented during a given session.

Except for the duration of the signals, the intervals within each trial were constant throughout the experiment: the ready period was 1.0 sec., the intersignal interval was 0.8 sec., the response interval was 2.0 sec., and the intertrial interval was 2.0 sec. During the intertrial interval the background noise was turned off. Its offset identified the end of the response interval, and its onset the start of the next ready period.

On each trial one of four possible pairings of signal intensity was presented: two 106 db tones (S_{HH}), two 86 db tones (S_{LL}), a 106 db tone followed by an 86 db tone (S_{HL}), or an 86 db tone followed by a 106 db tone (S_{LH}).

The eight trial types, consisting of four pairings of intensities and two orders of presenting the duration pairings (first or second signal longer), were presented in a new randomized order during each experimental session.

Results and Discussion

Table 1 presents both the proportion of correct responses, $Pr(C)$, made by each S with each of the 12 combinations of duration and intensity pairings, and the mean values of $Pr(C)$ for the 11 Ss. Figure 1 presents the mean value of $Pr(C)$ plotted against $D(t)$, with a separate curve for each of the intensity pairings. As would be expected, $Pr(C)$ is a decreasing function of $D(t)$.

The hypothesis that the accuracy of comparative time judgments is not related to intensity pairing is rejected ($p < 0.001$; Friedman Two-Way Analysis of

SUBJECT	D (0.5)				D (1.0)				D (1.5)			
	S_{HH}	S_{LL}	S_{HL}	S_{LH}	S_{HH}	S_{LL}	S_{HL}	S_{LH}	S_{HH}	S_{LL}	S_{HL}	S_{LH}
1	.99	.97	.85	.65	.87	.86	.66	.55	.65	.72	.68	.50
2	.91	.90	.90	.94	.86	.87	.85	.82	.78	.78	.78	.78
3	.95	.94	.93	.95	.79	.81	.80	.82	.78	.77	.79	.78
4	.93	.84	.74	.91	.85	.76	.68	.83	.74	.74	.66	.75
5	.88	.79	.76	.68	.76	.73	.69	.66	.66	.62	.66	.61
6	.77	.70	.66	.74	.64	.61	.67	.67	.62	.56	.59	.64
7	.96	.92	.91	.91	.80	.81	.75	.79	.72	.72	.67	.73
8	.63	.62	.63	.64	.60	.57	.56	.58	.58	.57	.53	.54
9	.96	.93	.90	.87	.80	.75	.75	.82	.66	.65	.68	.67
10	.73	.70	.65	.69	.66	.64	.62	.60	.60	.59	.59	.56
11	.92	.92	.86	.91	.82	.79	.75	.73	.70	.68	.64	.66
MEAN	.88	.84	.80	.81	.77	.75	.71	.72	.68	.67	.66	.66

Table 1. $Pr(C)$ for S_{HH} , S_{LL} , S_{HL} , S_{LH} under the three duration pairings for individual Ss, and averaged for the 11 Ss.

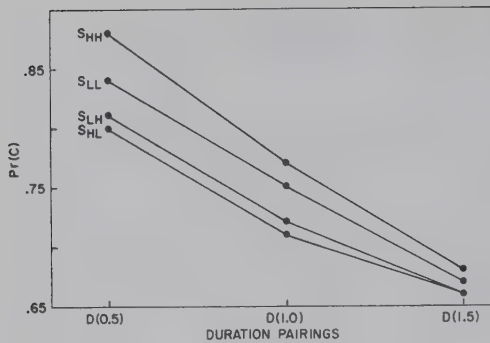


Fig. 1. Mean probability of a correct response.

Variance; Siegel, 1956). As shown in Fig. 1, the S_{HH} comparisons were the most accurate. This superior accuracy with S_{HH} does not support Creelman's conclusion that the intensity of a tone affects the accuracy of judging its duration only so far as detecting the tone is involved. Both the 106 db and the 86 db tones were clearly detectable in the background noise of 56 db. Creelman's conclusion was based on Ss' comparisons of signals of the same intensity only. When only S_{HH} and S_{LL} are considered in the present experiment, the hypothesis that accuracy of performance is unrelated to intensity pairing is again rejected ($p=0.02$; Sign Test; Siegel, 1956). Comparisons of the duration of tones of the same intensity (S_{HH} and S_{LL}) were more accurate than the comparisons of tones with different intensities (S_{HL} and S_{LH}), ($p=0.033$; Sign Test).

On the trials with different intensities (S_{HL} and S_{LH}) the overall probability of judging the 86 db tone to be longer than the 106 db tone was 0.48. This suggests an absence of bias toward judging either of the two intensities as longer, since each was in fact longer on half of these trials. That this unbiased behavior was typical is suggested by the fact that the probability of calling the 86 db tone longer was between 0.44 and 0.56 for 8 of the 11 Ss.

When the results reported here are considered in relation to those obtained with different modalities, several conclusions are suggested. Comparative judgments of duration are more accurate when the two signals being compared are alike than when they are different, either in modality or, in the case of tones, in intensity. Also, changes of either the tone intensity or the modality influence accuracy, such that the durations of tones of higher intensity and the durations of tones rather than lights are compared more accurately. Whereas it was reported previously that S's judgments were biased toward calling lights longer in duration

than tones, no such bias was found regarding the two tone intensities.

Certain aspects of the data reported here can be given a fairly simple theoretical interpretation. Assume that the onset and offset of the tone marking a temporal interval determine the "on-period" of an internal clock that behaves as a Poisson counter. For the two-alternative, forced-choice task assume that on each trial separate counts are made for the first and the second temporal intervals. The values of these two counts are denoted as c_1 and c_2 . S then compares the two counts against a criterion x and responds according to the following rule:

Select interval $\left\{ \frac{1}{2} \right\}$ as longer if $c_1 - c_2$ is $\left\{ \begin{matrix} > \\ < \end{matrix} \right\} x$. For $x=0$, S judges the first interval to be longer, if $c_1 > c_2$; whereas if $c_1 < c_2$ he judges the second interval longer.

Assume that the rate at which a counter is driven is a function of the intensity of the tone; the more intense the tone, the faster the counter. From this model the probability of a correct response, conditional on the various intensity pairings, is predicted to be:

$$\Pr(C | S_{HH}) > \Pr(C | S_{LL}) > \Pr(C | S_{HL}) = \Pr(C | S_{LH})$$

Furthermore, the model predicts that all of these probabilities will decrease, approaching 0.50 as $D(t)$ increases and Δt remains constant. A similar account may be given for the results of the cross-modality study cited previously, if it is assumed that auditory signals induce a faster counting rate than visual signals.

Although the model provides a good account of the simpler aspects of these data, some of the more detailed features require a more complex formulation. For example, the model, as it has been presented, assumes that the counting rate is independent of $D(t)$. However, if the counting rate associated with either the high or the low intensity tone is estimated from the data of the present experiment, the rate per unit time tends to decrease as $D(t)$ increases. Furthermore, as $D(t)$ increases, it appears that the counting rates for both high and low intensity tones approach a common asymptote. A more detailed theoretical evaluation of these data and the results of research currently being conducted will be given in a later paper.

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Note

1. The authors wish to express their appreciation to Julie Sadenwater for her assistance in collecting the data.

GSR and polarization capacity of skin

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By applying a square voltage pulse to skin through GSR electrodes and observing the voltage waveform across a small series resistance, the conductivity of skin may be seen to decrease sharply (e.g., by 80% or more) during the first 50 to 500 microseconds to a steady-state or DC value. At the end of the pulse, a back e.m.f. may be observed across the skin, equal to, e.g., 80% of the pulse voltage and opposite in polarity. During the GSR this polarization voltage decreases, producing an increase in apparent DC conductance, while the initial peak conductance does not change. This indicates that the GSR involves a change in polarization capacity of some membrane(s) in the epidermis.

When a voltage pulse is applied across skin, the current which initially flows through the tissue falls rapidly to a fraction of its peak value, as illustrated in Fig. 1. Since the voltage pulse is of constant amplitude, the pulse amplifier having a low output impedance, this current curve indicates a sharp drop in skin conductance to an asymptotic level equivalent to that which would be measured by the usual DC method. When the applied voltage is removed (i.e., at the end of the pulse), a back e.m.f. or polarization voltage may be observed across the skin; this voltage is discharged by a backward flow of current, represented by the negative spike on the right of Fig. 1, and is equal to about $(1 - C_{dc}/C_{pk})$ times the voltage of the applied pulse,

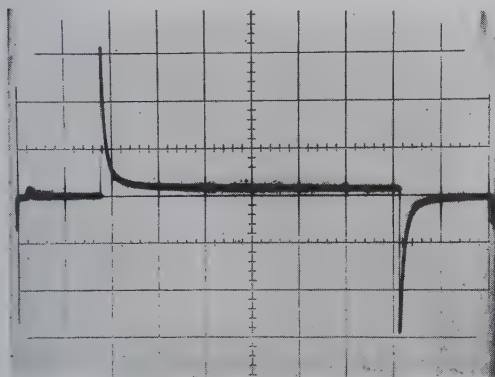


Fig. 1. Oscilloscope trace of current through the skin when a 0.5 volt square pulse of about 1.2 msec. duration is impressed across the tissue. Horizontal time axis is 0.2 msec. per large division; vertical current (conductance) axis is 50 microamps (or 100 micromhos) per large division. Pulse was applied between two finger electrodes, each covering about 7 cm^2 of intact skin. The initial or ohmic conductance is about 310 micromhos, the steady-state or DC conductance about 20 micromhos, and the back e.m.f. (producing the negative-going current spike of 147 microamps through the ohmic skin conductance) may be computed as $(147 \times 10^{-6}) / (310 \times 10^{-6}) = 0.47$ volts.

where C_{dc} is the asymptotic or DC conductance and C_{pk} is the initial peak or ohmic conductance.

This behavior may be explained as follows. The resting skin has a certain maximum ohmic conductance determined by the density of active sweat glands (which provide a low resistance shunt through the dry layers), by the size and concentration of ionic charge carriers, and by the size and density of pores in the interposed membranes, particularly the cutaneous membrane which is superficial to the Malpighian layer. But the cutaneous membrane adsorbs anions which become fixed negative charges in or near the pores of the membrane (Sollner, 1955). The "counter ions" of these fixed wall charges, small cations paired to the fixed anions by electrostatic attraction, have some freedom of movement through the pores in either direction. An external voltage applied across the membrane causes these counter ions to move through the pores in the direction of the negative pole until backward attraction toward the fixed wall charges prevents further movement, producing an ionic double-layer which acts as a battery in series-opposition to the applied voltage. Therefore, during the 50 to 500 microseconds required for this ionic reorientation to take place, current through the membrane falls from the peak value, equal to the applied voltage, E , times the ohmic conductance, C_{pk} , to a minimum steady-state (DC) value which is well enough approximated by subtracting the back e.m.f. of polarization from E and multiplying this residual effective voltage by the ohmic conductance, C_{pk} .

When the GSR is measured as a transitory increase in admittance of the skin to an alternating current, this admittance GSR gradually disappears as the frequency of the applied AC rises above about 10,000 cps. This was observed by McClendon & Hemingway in 1930 and again by Forbes & Landis in 1935 and interpreted by these authors to indicate that the GSR consists of a transitory decrease in the polarization capacity of the tissue, having the effect of increasing the residual voltage across the tissue and thus increasing apparent conductance. If one accepts the polarization hypothesis, then one expects that the limiting value of the AC admittance of skin as frequency increases will be the ohmic conductance. Hence, on this hypothesis, the failure to observe the GSR at high frequencies is a fairly compelling proof that the GSR does *not* involve a change in ohmic resistance, e.g., that the GSR is not a mere increase in the number of current paths due to increased sweat gland activity, nor an increase in the permeability of some interposed membrane.

But the polarization hypothesis has not been universally accepted and, in particular, some authors attribute

to the skin a considerable literal capacitance, similar to the capacitance across the cell membrane, and regard the decrease in skin impedance with increasing frequency to be primarily due to the change in capacitative reactance. If that were the case, then the GSR might indeed be a decrease in ohmic resistance which simply cannot be observed at high frequencies due to the much larger shunting effect of skin capacitance. The present experiment tests the polarization hypothesis in a more analytic fashion by observing the change in current through the skin during the application of a square pulse of (constant) voltage across the skin.

Method

Three zinc electrodes (Lykken, 1959) on the palmar surface of the distal phalanges of three fingers of one hand were connected together to serve as the active electrode, giving a total area of about 2.1 cm^2 . The reference was another zinc electrode over a drilled site on the forearm (Shackel, 1959). The electrolyte was a 0.07 molar solution of ZnSO_4 in a neutral ointment cream (Unibase). The S was wired in series with a small signal resistor and the output of the pulse amplifier (an AEL 104A stimulator in some of our work, e.g., Fig. 2, or a special power amplifier fed by Tektronix 161 pulse generators, e.g., Fig. 1). One channel of a Tektronix 502 dual-beam oscilloscope monitored the 0.5 volt pulse across the skin while the second channel was connected to the series resistor to read the current through the tissue (only the waveforms from this channel are shown in the figures). The total series resistance being small relative to the resistance of the S, the voltage waveform across the skin remained square and constant in spite of changes in skin conductance of the sort shown in the figures.

Results

The current waveform on the left in Fig. 2 was obtained while the S was at rest just before the GSR. The waveform on the right was obtained about 5 sec. after stimulation (a slap), during the GSR. It is apparent that the GSR involves a decrease in back e.m.f. (from about 0.42 to 0.37 volts in this instance) which increases the steady-state level of current flow, giving the appearance of an increase in conductance (from about 33 to 47 micromhos). If there is any change in the ohmic component of conductance, as measured by the height of the positive-going spike, it is too small relative to the change in back e.m.f. to be

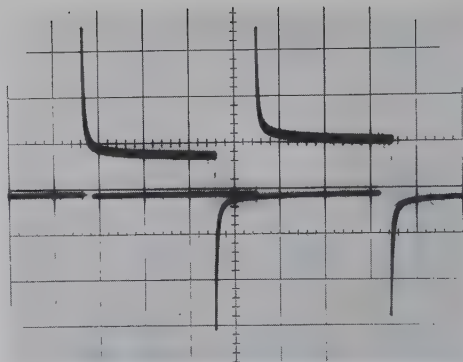


Fig. 2. Current waveforms through the skin before (left) and during (right) a GSR. Voltage applied was a 0.5 volt, 15 msec. square pulse, between a drilled reference electrode on the forearm and three $.7 \text{ cm}^2$ active finger electrodes connected together. Horizontal time axis is 5 msec. per large division; vertical current (or conductance) axis is 20 microamps (or 40 micromhos) per large division. Initial or ohmic conductance is about 140 micromhos both before and during the GSR. Steady-state or DC conductance is about 33 micromhos before and 47 micromhos during the GSR. The back e.m.f., computed as negative peak current divided by the ohmic conductance, is about 0.428 volts before and 0.385 volts during the GSR.

detectable by this method. Therefore, changes in conductance of tissues surrounding the cutaneous and sweat gland membranes or in the ohmic conductance of the membranes themselves are apparently much less important than the change in the polarization capacity of either or both of these membranes in producing the GSR. The manner in which the sudomotor impulse produces this change in polarization capacity remains obscure.

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Stimulus duration effects on secondary reinforcement¹

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Delay of primary reinforcement in training and stimulus duration in extinction were manipulated with kindergarten children as Ss on a push-button task. Each S was exposed to two different potential secondary reinforcers (PS^rs) (red and orange lights) for two different stimulus durations (10 sec. and 1 sec.) in training; and one PS^r duration combination (either red-1 sec., red-10 sec., orange-1 sec., or orange-10 sec.) in extinction. The PS^r duration in extinction could be the same or different from any PS^r-duration combination experienced in training. Control groups received the same schedule of 1 and 10 sec. trials in training, but the PS^r was a white light for both durations. Ss responded at a higher rate with a 10-sec. stimulus following a response in extinction than with a 1-sec. stimulus. There were no significant differences between experimental and control groups. Results were interpreted in the light of magnitude of reinforcement, and the discrimination hypothesis.

The purpose of this experiment was to examine, with children as Ss, the effects of a delay of primary reinforcement in training, and stimulus duration in extinction, on the secondary reinforcing value of a stimulus. Although delay has been demonstrated to be an effective learning parameter in the child literature (Walters, 1964; Etzel & Wright, 1964; Lipsitt & Castaneda, 1958), experiments concerned with secondary reinforcement have focused on the effects of other major parameters of reinforcement, percentage and amount (Myers, 1958).

In the present study, the duration of the potential secondary reinforcer (PS^r) was manipulated both in training and extinction. Each S was exposed to two different stimulus durations in training (10 sec. and 1 sec.), and one in extinction (10 sec. or 1 sec.). Two stimuli were used as PS^rs in training, one for each duration. Only one of the stimuli presented in training was used as the PS^r for extinction. The PS^r-duration combination which followed a response in extinction could be the same or different from any PS^r-duration combination experienced in training. According to the discrimination hypothesis (Bitterman et al, 1953; Myers & Myers, 1965), those groups with a novel PS^r-duration combination in extinction should respond at a lower rate than the groups with a combination they have already experienced.

Method

The Ss were 96 children attending kindergarten and nursery schools in Northampton, Massachusetts. The apparatus and general procedure have been described previously (Myers & Myers, 1965).

Training for the experimental groups consisted of 80 trials; for 40 of these, a button press led to a light of 1 sec. duration (1), while for the other 40 trials, a button press led to a different color light of 10 sec. duration (10). The 1 sec. and 10 sec. lights were presented randomly, followed on 20% of the trials by a candy, the candy being equally distributed between the 1 and 10 sec. trials. The groups were counterbalanced with respect to the color light (red or orange) associated with a given duration. The control groups received the same schedule of 1 and 10 sec. trials, but the stimulus was always a white light during training.

During extinction, each S experienced a light whose color (red or orange) and duration (1 or 10 sec.) was the same after every button press. The groups differed with respect to two factors: (a) the color used in extinction might have been previously present for 10 sec., 1 sec., or not present (control) during training; (b) the color appeared for either 1 sec. or 10 sec. following each extinction response. The six groups are labeled 1-1, 10-1, C-1, 1-10, 10-10, and C-10, where the first designation refers to duration of the extinction color in training, the second to duration of the extinction color in extinction.

Throughout the training and extinction periods, S was allowed to respond at his own rate. Time to complete training was recorded. During the extinction period, E recorded the number of button presses per minute until S chose to stop, or until the end of 20 min. at which time E terminated the session.

Results and Discussion

Because Ss were unable to respond again until the termination of the light stimulus, and since the 10 sec. stimulus eliminated responding for a much longer period, it became necessary to equate the maximum number of possible responses per minute for the groups receiving 1 sec. and 10 sec. stimuli in extinction. Therefore, the number of responses for the 10 sec. group was multiplied by a factor of 10. The average number of responses for each 4-min. block of extinction for each group is shown in Fig. 1. Ss responded at a higher rate with a 10 sec. stimulus following a response in extinction than with a 1 sec. stimulus ($p < .001$).

The lack of differences as a function of training, between the experimental and control groups, indicates that the difference found as a function of stimulus duration during extinction, rather than any specific secondary reinforcement effect, may be a simple preference for a long rather than a short stimulus, as

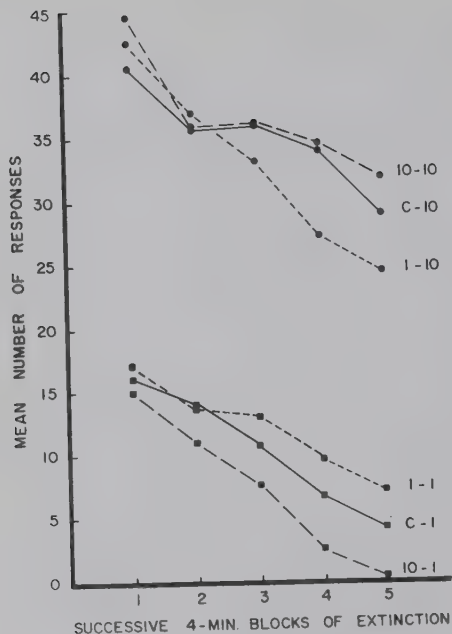


Fig. 1. Mean number of responses for successive four-minute blocks of extinction.

would be predicted by any magnitude of reinforcement theory (Pubols, 1960). It is also possible that the control groups, although trained with white lights, simply generalized secondary reinforcing characteris-

tics to the colored light used in extinction. Further research into the phenomenon of generalization of secondary reinforcement should prove interesting.

The usual decrease in response rate over time blocks in extinction was also significant ($p < .001$). Within each duration condition, the groups receiving the same light-duration compound in extinction as they experienced in training (1-1, 10-10) responded more than the groups in which this compound differed from training to extinction (1-10, 10-1). Although the interaction was not significant, this trend is in agreement with predictions of the discrimination hypothesis of extinction behavior.

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Note

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Anagram solution as a function of pronounceability and difficulty

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The present study investigates the effect of pronounceability (P), as rated by Ss, on anagram solution probability under two levels of difficulty (D), or number of letters moved. From 60 five-letter anagrams rated for P, four lists of 10 anagrams each were constructed to represent both easy-to-pronounce and hard-to-pronounce anagrams in both levels of D (one vs. two letters moved). The results indicate that P is inversely related to solution probability, and that D is not an effective variable with hard-to-pronounce anagrams.

Ekstrand & Dominowski (1965), supporting the Beilin & Horn (1962) study, have demonstrated that non-word anagrams are less difficult to solve for other words (e.g., *teirw* for *write*) than word anagrams for other words (e.g., *melon* for *lemon*). The former investigators suggest that representational responses necessary for the perception of the stimulus, as well as implicit associative responses, interfere with solution. The latter investigators suggest that S perseverates on the sound or meaning of the word anagrams. Recently, however, Mayzner & Tresselt (1965) presented evidence that there is no difference in solution times of word and non-word anagrams. This discrepancy of results suggests that perhaps an alternate approach is needed to elucidate the problem of word vs. non-word anagrams.

It is reasonable to consider words more pronounceable than non-words. It is equally reasonable to consider some non-words more pronounceable than other non-words. In light of the Beilin & Horn (1962) and Ekstrand & Dominowski (1965) findings, it is suggested that pronounceability (P) may interfere with word anagram solution. If this is the case, it follows that P should have a similar, though perhaps reduced, effect on the solution of non-word anagrams. For example, if one takes two anagrams of equal letter order difficulty and Thorndike-Lorge frequency, e.g., *crove* (solution-cover) and *mcusi* (solution-music), Ss should rate *crove* higher in P than *mcusi*. Differences in solution probabilities may then be attributable to P. This study investigates the effect of P, as rated by Ss, upon the probability of solution of non-word anagrams under two levels of difficulty (D), or number of letters moved.

Method

Materials. Thirty Thorndike-Lorge AA nouns were randomly chosen as potential solution words from a list of five-letter nouns beginning with consonants. Sixty anagrams (30 one-letter move and 30 two-letter move problems) were then constructed by E so as to lend themselves easily to division into high pronounceability (HP) and low pronounceability (LP) categories.

Two hundred and ten Ss then rated the 60 anagrams on a 1 to 5 scale for P (low to high). Each S rated a list of 10 anagrams presented in a random sequence or its inverse. All lists contained expected HP and LP problems. Each anagram was rated by 35 Ss. This procedure yielded four types of anagrams: (1) HP one-letter move or "easy" anagrams (HP-E), (2) HP two-letter move or "hard" anagrams (HP-H), (3) LP one-letter move anagrams (LP-E), and (4) LP two-letter move anagrams (LP-H). The 10 items having the smallest variance in each of the four categories of anagrams were then selected for one of four lists, since no overlap in ratings of the expected HP and LP items occurred. The HP-E list, (e.g., *patin*, *crove*, and *larbo* with solutions—paint, cover, and labor) had a mean P rating of 4.66, and a range of 4.91 to 4.34, while in the HP-H list (e.g., *rocut*, *sumic*, and *doblo* with solutions—court, music, and blood) the mean = 4.59, and range = 4.94 to 4.29. In the LP-E list (e.g., *sgaru*, *mcusi*, and *trnai* with solutions—sugar, music, and train) the mean = 2.29, and range = 2.63 to 1.86, while in the LP-H list (e.g., *drkni*, *ifgth*, and *mnoye* with solutions—drink, fight, and money) mean = 1.98, range = 2.57 to 1.45. Some of the solutions, e.g., *sugar*, were used in more than one list. Note that bigram frequency (Mayzner & Tresselt, 1959) was not controlled in the lists. Since experimental control was found to be impractical, statistical control of bigram frequency was then used.

The 10 items for the four lists were placed on an 8-1/2 in. x 5-1/2 in. verbal booklet so that only one item could be seen or worked on at a time. The booklet consisted of 12 pages: a cover page, an instruction page, and 10 problem pages. One problem was dittoed on the center of each page, with all of the letters capitalized and one typewriter space apart.

Subjects and procedure. Employing a 2 by 2 factorial design, 240 additional Ss were assigned to the test session. All of the Ss in the rating and testing sessions were introductory psychology students. Sixty Ss were randomly assigned to a list, with six Ss assigned to each of 10 orders of a given list. Upon receiving general instructions, Ss turned to the instruction page where they were told what an anagram was and what the task was. E then paced the group of 260 Ss through the 10 items, allowing 13 sec. per problem and a 2 sec. inter-item interval.

Results and Discussion

The analysis of covariance technique was used to control for bigram frequency, as calculated by the Underwood & Schulz (1960) counts. Bigram frequency of a given

anagram was treated as a covariate with the total number of solutions for that anagram. After correction for the effects of bigram frequency, P was found to be significant at the .001 level ($F=28.06$, $df=1/35$) whereas D was not significant ($F=0.16$, $df=1/35$). The P by D interaction, however, was significant at the .01 level ($F=8.10$, $df=1/35$). As expected, the LP-E and LP-H lists yielded higher mean number of solutions (6.90 and 4.24 respectively) than did the HP-E and HP-H lists (3.03 and 3.31 respectively). Note that these values for means are corrected means based on the analysis of covariance (Fig. 1). Since LP-E and HP-E lists were expected to be less difficult than their counterpart H lists, a slight reversal occurred with the HP-E and HP-H list means. Orthogonal comparisons, however, indicate that no significant difference exists between the HP-E and HP-H means.

These results demonstrate that P is inversely related to solution probability, which lends support to the Beilin

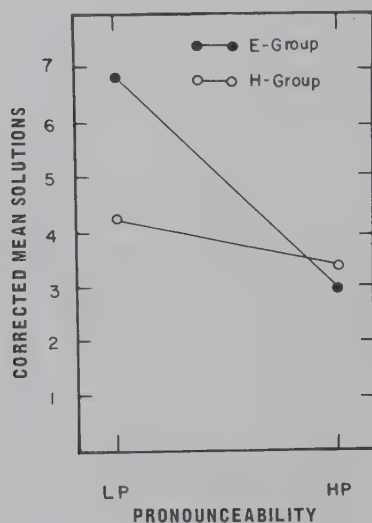


Fig. 1. Corrected mean number of solutions for E and H groups as a function of P.

& Horn (1962) and Ekstrand & Dominowski (1965) findings. Further, since the HP-E and HP-H groups appear to be essentially equal, the P by D interaction is interpreted to mean that D is an effective variable only in the absence of the HP condition. It could be that P is so effective in the HP condition that the effects of D are nullified.

The finding of greatest importance is the inverse relationship between P and solution probability. It seems quite likely that HP anagrams are more readily encoded than LP anagrams. It is reasonable to consider HP items more "collapsible" into an encodable unit than LP problems, by virtue of P. When confronted with an anagram, S attempts to encode the stimulus as a unit because of prior reading habits. In order to accomplish this with LP anagrams, S may immediately have to rearrange the combination of letters to perceive an encodable unit, whereas the HP problem is encodable as is. The immediate rearranging of LP anagrams increases the probability of solution relative to HP items.

The discrepancy between the Beilin & Horn (1962) and Ekstrand & Dominowski (1965) studies vs. the Mayzner & Tresselt (1965) finding perhaps is attributable to effects of P. According to the above hypothesis, a sample of non-word anagrams equal in P to a sample of word anagrams should have equal solution probabilities. Therefore, the problem of word vs. non-word anagrams is meaningful only in terms of P under this hypothesis. It should be noted, however, that associations to a stimulus could also interfere with solution as Mayzner & Tresselt (1965) and Ekstrand & Dominowski (1965) have both suggested. Such interference, however, may serve to augment the effect of P since the most readily encoded problems will most likely be first to produce associations.

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A technique for the study of steady-state short term memory

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Steady-state STM was studied by a method in which S was required to keep track of the randomly changing response member of each of 5 stimulus words. On each of 220 consecutive presentations, S had to recall the response last paired with a given stimulus and then had to learn a (possibly) new response to the same stimulus. A measure of S's STM was his proportion of correct recalls as a function of the number of items intervening between successive appearances of a given item. Results suggest that the method gives a stable measure of STM. Specifically, proactive effects appeared to be constant throughout the sequence of presentations.

Recently, several investigators have studied short-term memory (STM) by means of steady-state procedures, i.e., procedures in which S is repeatedly required both to learn new items and to recall old items where both tasks are mixed in a long sequence (e.g., Shepard & Teghtsoonian, 1961; Hinrichs, 1966). This paper presents a new steady-state method together with data which suggest its validity. Steady-state techniques have many advantages over methods in which S is presented with short sequences of items to remember which are tested for recall only at the end of a given sequence (e.g., Peterson & Peterson, 1959; Waugh & Norman, 1965). The steady-state techniques are more efficient in collecting data, are free of primacy effects, and test STM in a relatively more stable context than the short-sequence methods.

The method presented in this paper permits any number of combinations of stimuli, responses, and presentations to be used. In addition to the advantages described above, of steady-state procedures, it has, in paradigm, important similarities to both the anticipation method of paired-associates learning and probability learning. Therefore, validation of the present method would aid in placing the study of STM in a wider context.

In outline, the method is as follows. A test item (a stimulus word) is presented to S who attempts to recall the response member previously associated with it. Then, the test item is replaced by a reinforced item which is the same stimulus word with a response member added. The response member may or may not be the same response which was previously paired with that stimulus word. Thus, S receives no feedback as to whether or not he correctly recalled the response previously associated with that stimulus word. Instead, he must try to learn a (possibly) different response to the same stimulus. The next presentation begins with the appearance of a (possibly) different test item. Again,

S attempts to recall the response last associated with that stimulus word. Then, that stimulus word is reinforced with a response that may be different from the response last associated with that stimulus word. Test items alternate with reinforced items in a long sequence of alternations (for example, 200 presentations). Each of a set of stimulus words appears several times in the sequence. The main variable of interest is S's frequency of correct recalls as a function of the number of reinforcements and tests intervening between successive appearances of a given item; this number is defined as lag. Note that each presentation contributes two intervening items, one a test and the other a reinforcement.

Method

Five stimuli, the letter-rows BBBB, DDDD, GGGG, TTTT, VVVV, were used in two sequences of 220 presentations each. Each letter-row was assigned one of four responses for each reinforced presentation, the responses being the numbers 1, 2, 3, 4. For each sequence, the first 20 presentations were dummy presentations. In the remaining 200 presentations, each of the 5 letter-rows appeared in 40 presentations and each of the 4 response members was randomly paired 10 times with each letter-row. A reinforcement consisted of presenting a letter-row with one of the four positions enclosed in parentheses, e.g., BB(B)B, the reinforced item "B-3." A test consisted of presenting the letter-row without parentheses, e.g., BBBB. Tests and reinforcement appeared successively in a single window of a Stowe memory drum. Each item remained in the window for 3 sec. In between items, a shutter closed for 1 sec. S responded on reinforcements by saying aloud the letter and reinforced position (e.g., "B-3") and by saying aloud on tests the letter and the response he believed to be correct. S was instructed to guess if he did not know the correct answer. Before the sequence began, E gave S a starting-response for S to make to the initial appearance of each test stimulus.

Each sequence was constructed under the restriction that approximately equal numbers of each lag 0, 2, 4, ..., 16 occur for each item.² S was instructed that the probability of the same item appearing on successive presentations (i.e., a lag of zero) was 1/9 and that this was equal to the probability of any other lag 2, 4, 6, ..., 16 occurring. Also, S was told not to rehearse items after they had been presented. By these instructions, it was intended that S pay close attention to each test or reinforced item as it appeared and that S avoid grouping items, looking for "meaningful" subsequences, trying to find consistent differences among items, etc.

Each of six Ss was given one of two sequences on each of five consecutive days. For three Ss, the order of sequences was ABABA and for the other three Ss, BABAB. Ss were junior and senior women enrolled at the University of Connecticut. Each was paid \$10 for participating.

Results and Discussion

Of major importance is a check of the equilibrium properties of the method. Previous investigators (Shepard & Teghtsoonian, 1961; Hinrichs, 1966) found that pro-active interference did not increase steadily as the number of presentations increased. The present data support the suggestion that proactive effects are not large and, more importantly, do not operate differentially over the experimental session. Table 1 presents the mean proportion of correct responses in successive blocks of 25 presentations in each of 5 successive days. An analysis of variance was performed on the number of correct responses in successive blocks of 25 presentations in each day for each S. The effect of Blocks was not significant, and, in fact, its mean square was small ($F=1.16$, $df=7/35$). Neither was the Blocks by Days interaction significant ($F=1.00$, $df=28/140$). However, the effect of Days was statistically significant ($F=5.65$, $df=4/20$, $p<.01$). A Student-Newman-Keuls range test performed on the mean number of correct responses in each day suggested that there

Table 1. Mean Proportion of Correct Responses in Successive Blocks of 25 Presentations in Each of 5 Successive Days

Day	1	2	3	4	5	Mean
Block 1	.447	.567	.567	.587	.627	.558
2	.460	.487	.567	.640	.620	.555
3	.467	.440	.573	.613	.600	.546
4	.533	.507	.640	.667	.693	.608
5	.493	.513	.600	.667	.600	.575
6	.447	.433	.627	.587	.600	.546
7	.560	.367	.627	.620	.680	.571
8	.573	.480	.600	.700	.653	.601
Mean	.498	.474	.600	.635	.634	

Table 2. Mean Proportion of Correct Responses as a Function of Lag

Lag	0	2	4	6	8	10	12	14	16
p(c)	.987	.742	.669	.578	.556	.509	.532	.531	.501

were no significant differences among Days 3, 4, and 5 and there was no difference between Days 1 and 2. However, the difference between Day 1 and Day 3 was significant ($W_2=2.38$; $p<.05$), as was the difference between Day 2 and Day 3 ($W_3=2.89$; $p<.05$). The results suggest that two practice sessions were necessary to stabilize Ss' behavior.

A second index suggested that Ss' ability to attend to each item improved with practice. The mean proportion of errors given a lag of zero was .045 on Day 1 and .128 on Day 2. In contrast, the mean proportion of errors given lag zero was .019, .008, and .008 for Days 3, 4, and 5, respectively.

Table 2 presents the mean proportion of correct responses as a function of lag, averaged over Ss and Days 3, 4, and 5. The proportion of correct responses is reduced approximately 25% by two intervening items. Forgetting appears to asymptote at about lag 10.

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Notes

1. This research was supported by a grant from the Office of Research Development of the University of Connecticut Research Foundation. Suzanne Standish ran Ss and aided in analyzing data.
2. R. Bjork and R. Miller of the Institute for Mathematical Studies in the Social Sciences, Stanford University, constructed the algorithm and computer program used to generate item sequences.

Consolidation of word sequences as a function of rehearsal time and contextual constraint¹

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This study aimed to examine the effects of contextual constraint (CC) on short-term memory for words. Twenty-four Ss read and then rehearsed lists of 6 words which were either random or second-order approximations to English. They carried out a subtracting task before attempting recall of each list. Recall varied directly with time available for rehearsal (0, 3 and 6 sec. being used). At all rehearsal times constrained sequences were better recalled than randomly ordered word lists. A construction-at-recall explanation is not entirely satisfactory, and it is suggested that CC also affects the way in which lists are stored.

What underlies the observed effects of contextual constraint (CC) on recall of word lists (Miller & Selfridge, 1950, confirmed by e.g., Marks & Jack, 1952; Sharp, 1958; Richardson & Voss, 1960)? CC may have influence at the time of recall, when Ss can "construct" lists (Deese, 1961), basing their guessing on prior knowledge of the language, and lower the thresholds at which decisions can be made about the correctness of items-to-be-recalled by checking against such knowledge. The question is whether the effects of CC occur solely at this time, or whether it affects recall by influencing also the previous storage of the word lists. An approach to this problem is to observe the effects of rehearsal of word lists differing only with respect to CC. One would not expect length of rehearsal period greatly to influence the success of strategies at the time of recall. On the other hand, differences in the way word sequences are stored might well be reflected in correct recall of lists when time available for rehearsal is varied.

The dependent variable in this experiment is the resistance of word sequences which Ss are remembering to a distracting task. Such resistance, or consolidation, is measured by scoring the recall of lists by Ss after they have performed an interfering task. Rehearsal succeeded the presentation of 6-word lists (i.e., the longest lists for which recall by English undergraduates immediately after presentation or during the rehearsal period is rarely imperfect). Then followed an additional task, after which recall was tested.

Method

Twenty-four 6-word lists were taken from the second order approximations to English used by Taylor & Moray (1961). These will be called 'B lists.' The words constituting these lists were chosen at random to make a further 24 lists of 6 words each ('A lists'). For the interference task Ss had to subtract by sevens from a 3-digit number. They read aloud the original number (x),

and said the subsequent 3 residual numbers ($x-7$, $x-14$, $x-21$), simultaneously writing them down. Ss received a new number for each trial, within which all Ss in a group were given different numbers. Each commencing number for an interfering task was printed on the sheet of paper used by an S for subsequent recall of the word sequence.

The 24 Ss were randomly assigned to 3 approximately equal groups. They were each shown 48 lists, in 6 batches of 8. There were 3 values of the rehearsal-time variable, 0, 3 and 6 sec., and within batches the same value was used with all lists, Ss all seeing 2 batches of 8 lists coupled with each rehearsal-time. Orders of rehearsal-time batches were balanced between groups. Within each batch there were 4 A lists and 4 B lists, ordered randomly except that no runs of over 3 were included. Lists were projected for 3 sec. onto a large screen. Ss were told to watch each list until it disappeared, and then rehearse silently until a red lamp, placed just below the screen, was illuminated. In the no-rehearsal condition this coincided with the disappearance of the list. The lamp was the cue for Ss to start the interference task, on completion of which written recall was attempted. Ss had to write from left to right, above 6 printed dashes on recall sheets, so that position as well as order of words were as originally presented. About 30 sec. elapsed between the start of the interference task after one list and the projection of the next list. For practice, Ss had 4 trials of the interference task alone, followed by 9 trials of the full experimental procedure. Scoring was by ordered recall. To be correct a word had to be recalled in the original position in a list. E also counted items correct regardless of position, but the results obtained by this method of scoring are not included here. They contained no inter-condition differences to the results measured by ordered recall.

Results

Figure 1 shows the average number of words correctly recalled of both types of 6-word lists for all rehearsal times. B lists are better recalled than A lists at all values of rehearsal time ($p < .001$). With both types of list more is recalled when 6 sec. rehearsal precede the interference task than where no time is allowed for rehearsal ($p < .001$ for B lists, $< .01$ for A lists). There is clearly no interaction between the effects of type of list and length of time for rehearsal.

If the distribution of errors between serial positions in A lists is compared with the distribution to be expected if the errors in A and B lists were distributed

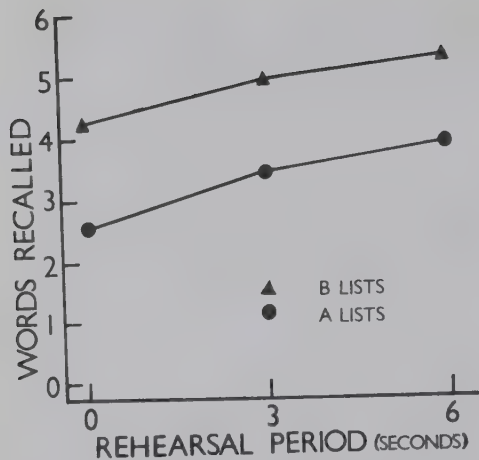


Fig. 1. Average number of words correctly recalled per list as a function of contextual constraint and rehearsal time.

identically among serial positions within conditions, there is no significant difference in shapes of distributions between A and B lists. ($\chi^2 = 8.61$ (5) for difference between A0 and B0; 3.34 (5) for A3 and B3; 4.96 (5) for A6 and B6. For all of these $p > .1$.) Averaged over all rehearsal times, the percentage of total errors occurring at each serial position never differs between list types by more than 2.1%. Total errors (out of 576) for positions 1-6 respectively are 153, 205, 267, 308, 259, and 180 in recall of A lists, and 62, 83, 109, 131, 113, and 93 in B lists.

Discussion

Retention of both random and constrained lists is less affected by a distracting task when time is allowed for rehearsal. The lack of an interaction between the effects of CC and rehearsal time should be interpreted with caution. An increase in recall difference after rehearsal would be a reasonable indication that B lists are more efficiently stored than A lists, although there is a complication in that the effect as well as the result of S performing an interfering task is not necessarily independent of prior level of retention. The absence of any increase in recall differences does not preclude a difference in storage efficiency. To maintain a constant differential in amount recalled over various rehearsal times more B list items than A list items would be required to profit by rehearsal in gaining resistance to the

subsequent interfering task. Further, the assumption that rehearsal would magnify differences in resistance to interference due to sequences being stored differently could be wrong.

A more satisfactory answer to the question of whether a construction-at-recall account alone is sufficient to explain the superiority in recall of constrained lists is obtained by a serial position analysis of errors. If the difference is largely due to construction, the probability of the item presented n th in a sequence of 6 words being recalled correctly, given that item $n-1$ is correct (where $6 \geq n \geq 2$) should be higher in B lists than in A lists. This is not the case in the present experiment, interposition distribution of errors being very similar for A and B lists. The related fact that words presented in the first position in lists are better recalled when followed by B than by A sequences cannot be explained by a construction-at-recall hypothesis, the ratio of errors in A lists to B lists for the word presented first being 2.5:1, which is higher than the corresponding ratio for any other serial position. In fact, there is no definite evidence that construction-at-recall is a cause of the greater recall of constrained than random sequences in the present experiment. The suggestion that the effects of CC on word recall scores are due to its affecting materials in store prior to recall, as well as any construction-at-recall effect, is supported by findings of Lachman & Tuttle (1965), who reached a similar conclusion by a study in which construction-at-recall was precluded by testing recognition, one word at a time.

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Note

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The rat's adjustment to the 23-hour water-deprivation schedule under two conditions of food availability¹

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Two groups of rats were placed on a 23-hr. water-deprivation schedule. Group F always had food available; Group NF had food available except during the daily 1-hr. water-intake period. Both groups adjusted to the schedule in 3 to 6 days; however, the weight of Group F increased after adjustment while weight of Group NF remained constant. The possibility that the groups differed in motivation level following adjustment was discussed.

Studies have found that the rat adjusts to the 23-hr. food-deprivation schedule in 15 to 20 days and to the 23-hr. water-deprivation schedule in 2 to 5 days (Dufort, 1963, 1964; Dufort & Blick, 1962; Fallon, 1965; Reid & Finger, 1955). Dufort, Rollins, & Funderburk (1965) observed, however, that these findings are limited to schedules in which the non-deprived substance (e.g., water for food-deprived Ss) is available during the daily 1-hr. period when the deprived substance (e.g., food) is available. There is little uniformity among Es who use deprivation schedules to control motivation in animal-learning studies with regard to whether or not they permit Ss to have the non-deprived substance with the deprived substance; indeed, many Es fail to report information on this matter. Since presence or absence of the non-deprived substance might affect adjustment, and since Ss should adjust before being introduced to the learning situation (Reid & Finger, 1955), comparisons of adjustment under the two conditions of availability of the non-deprived substance are needed. Dufort et al (1965) showed that the 15 to 20 day adjustment period needed for the 23-hr. food-deprivation schedule when water is given with food changes to an estimated 30 to 35 day period when water is not given with food. The experiment reported here is concerned with the effect on adjustment to the 23-hr. water-deprivation schedule of presence or absence of food during the daily 1-hr. drinking period.

Method

The experiment was run in two replications, identical except for number and age of Ss. In the first replication, two matched groups of eight Ss each, 127 days old, were formed on the basis of mean daily body weight during a six-day ad libitum base period; the second replication used two matched groups of five Ss each, 115 days old, formed in the same way. All Ss were male rats of the Holtzman strain, housed in individual living cages. After the base period, both groups in each replication were placed on a 23-hr. water-deprivation schedule for 21 days; water was given only from 2:00 P.M. to 3:00

P.M. daily. For Group F, Purina lab chow pellets were always available; for Group NF, pellets were available at all times except during the 1-hr. drinking period. Measures taken for all Ss were body weight at 2:00 P.M. and water intake during the daily 1-hr. period.

Results

Adjustment trends were similar in both replications; therefore, only data from the first replication will be presented. In Table 1, weight and intake measures for the 21 days of deprivation appear. Day-0 weights were obtained on the day after the base period, just before deprivation started. The difference in Day-0 weights for Groups F and NF was not significant in either replication ($p > .05$).

With regard to adjustment trends, Table 1 shows that Group F lost weight for three days and then gradually gained weight. Group NF also lost weight for 3 days but failed to gain thereafter. The water intake of Group F increased for 5 to 6 days and remained stable thereafter. Similarly, intake of Group NF increased for 6 days before reaching stable values. As would be expected, mean daily water intake of the group with food during the drinking hour (Group F) was significantly greater than the intake of Group NF in both replications ($p < .05$).

Table 1. Mean body weight and water intake for the groups in the first replication (N=8 in each group)

Day	Group F		Group NF	
	Weight (gm)	Intake (ml)	Weight (gm)	Intake (ml)
0	439.0		438.2	
1	411.4	18.6	411.3	15.8
2	405.6	22.0	406.4	17.8
3	405.4	22.9	404.3	19.3
4	406.3	23.9	405.1	19.8
5	407.1	25.9	404.3	20.1
6	407.0	26.1	405.6	22.0
7	407.5	25.8	404.9	21.0
8	409.6	26.3	405.4	20.7
9	409.3	26.4	405.2	21.8
10	410.4	26.0	404.8	20.4
11	410.7	26.7	405.4	21.9
12	411.3	27.3	405.6	22.8
13	413.0	25.7	408.7	22.7
14	412.8	26.1	406.2	22.2
15	413.9	24.8	404.6	23.1
16	414.2	26.3	407.2	22.5
17	415.6	25.9	406.9	22.6
18	416.3	27.0	407.1	22.1
19	416.5	26.4	405.8	21.3
20	418.6	25.7	407.0	22.0
21	419.7	26.5	406.7	20.8

Discussion

The weight and intake trends for Group F show adjustment to the schedule in 3 to 6 days, as expected from previous research. The trends for Group NF also show adjustment in 3 to 6 days. Thus, although removing water during the eating hour virtually doubles the adjustment time for the 23-hr. food-deprivation schedule (Dufort et al, 1965), presence or absence of food during the drinking hour has no effect on the adjustment time for the 23-hr. water-deprivation schedule. The chief effect of the food variable is, rather, on weight trends after adjustment. Group F shows a steady increase in weight after Day 3, a trend seen previously for Ss on this schedule (Dufort, 1963). Group NF shows a surprisingly stable weight level following adjustment. This stability of weight, however, has not been universally found; Kutscher (1964), for example, reports a modest weight gain following adjustment for Ss on a 23.5-hr. schedule that omitted food during the .5-hr. drinking period. This discrepancy between Kutscher's results and the present results could be due to the different temporal features of the two schedules.

More to the point, for the E using water deprivation in studies of learning, is the possible implication for the motivational level of the Ss of the difference in post-adjustment weight trends in Table 1. Using bar pressing as a behavioral index, Davenport & Goulet (1964) report that Ss kept at a constant weight following adjustment to a food-deprivation schedule undergo an increase in motivation as a result of failure to maintain a normal growth rate. Ss on a schedule which permitted

them to gain weight after adjustment, however, showed evidence of remaining at a relatively constant motivational level. The weight trends of Groups F and NF bear an obvious similarity to the weight manipulations used by Davenport & Goulet. Whether their results with food deprivation would be obtained using the water-deprivation schedules of the present study can only be determined empirically.

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Notes

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2. Now at University of California, Los Angeles.

Color preference in squirrel monkeys (*Saimiri sciureus*)

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Eight naive squirrel monkeys were found, by the paired comparisons method, to prefer darker-hued colors.

The purpose of this experiment was to find, prior to color discrimination training, if monkeys were biased towards any particular color or part of the color spectrum and, if so, to determine the strength of the bias.

Method

The apparatus used was a sheet metal cubicle which contained two display panels mounted side by side in one wall (Fig. 1). Each display panel contained a pair of holes behind which the stimuli could be mounted and a third hole for access to a delivery cup. A pair of guillotine screens covered each display panel: the outer screen was opaque to prevent S from seeing the discriminanda between trials and the inner one was transparent to prevent S from touching the stimuli prior to a brief exposure period at the start of a trial. The display panels were flat white, the opaque screens flat gray, and the remainder of the apparatus was flat black. Stimuli were colored cards which served also as manipulanda.

Eight naive adult squirrel monkeys (4 males and 4 females) were trained to press the stimulus cards by an approximation method. After magazine training, the Ss were required in successive stages to press a transparent card behind which a pellet was shown, to press an opaque card which had a pellet lodged between its base and its holder, and finally to press an opaque card with no pellet present. Each pretraining press resulted in delivery of a CIBA 75-mg banana pellet into the nearest food cup.

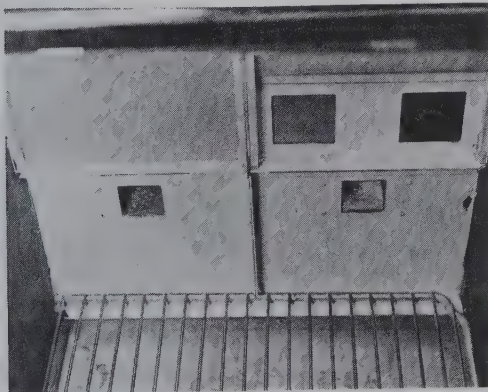


Fig. 1. The interior of the discrimination apparatus with guillotine screens raised to show one display panel and a pair of stimuli.

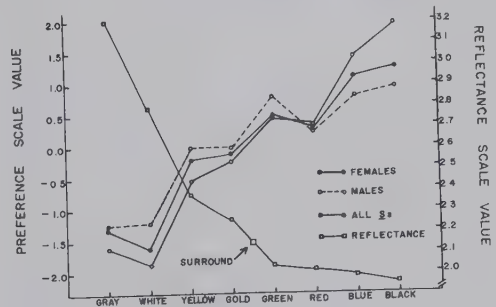


Fig. 2. Results of the first preference test, showing color preference scales for males, females, and both groups combined, and reflectance curve for the eight colored stimuli. Preference values are standard deviations and reflectance values are averaged readings from an exposure meter scale.

The color preference test was administered by the paired comparisons method. The stimulus colors were Pleasuretone enamel made by Star Bronze Co., Alliance, Ohio, and in order of reflectance as measured under standard conditions were gray, white, yellow, gold, green, red, blue, and black (cf. Fig. 2). Although nearly indistinguishable in terms of reflectance, the latter four stimuli were easily distinguishable to the monkeys, hence, although technically incorrect, all colors as listed above will be referred to as lying on a dimension from bright-hued to dark-hued. The reflectance of the display panels was intermediate between gold and green. Each possible pair of different colors was presented four times in a random order which allowed counterbalancing of the side of the apparatus on which the pair was presented and the position of each stimulus within the pair. All 112 responses in the preference test were rewarded.

A second test for color preference was given after completion of a conditional-outcome choice experiment (Green & Moore, 1966). Six monkeys which had not position responded for more than 10 consecutive days in that experiment were used as Ss. The procedure was identical to that in the first experiment, but the display panels and guillotine screens were painted flat black and the remaining walls of the apparatus were painted flat white in an attempt to find if the original preferences were based on color or on contrast between the stimuli and the surround.

Results

Pretraining required 30-60 days, and the females took nearly twice as long as the males to learn the panel press response.

In the first preference test, seven Ss position responded on 61-74% of the trials, and one male position responded on 90% of the trials. In Fig. 2 are shown preference scales for the males, females, and both groups combined, constructed according to procedures given by Torgerson (1958, pp. 168 ff.). Thurstone's Case IV was used instead of the more popular Case V because the discriminial dispersions of the stimuli were unequal. The scales show that the darker-hued the color the greater the preference. Also, the preferences of the females tended to be stronger than those of the males. One notable inversion of preference occurred at the red stimulus, with the females appearing more "averse" to this color than the males.

In the second preference test, position responding increased in all animals such that the lowest percentage was 76% responses to the preferred side. The tendency to prefer darker-hued colors was still present, but, in that only 52.3% of the responses were made to the four darkest-hued stimuli, the preference was greatly diminished and far less clear-cut than in the first test.

Discussion

It may be questioned whether the obtained preferences were based on color or on reflectance. Insofar as the darkest-hued stimuli were nearly indistinguishable in

terms of the reflectance measure and the animals differentiated among them quite nicely in terms of the preference measure, the preferences appear to be based on color. In addition, contrast between the stimuli and the surround did not appear to affect preference because the preference curve in the first test was symmetrical about the middle reflectance value (that of the surround) and because the preferences in the second test were grossly similar to those in the first test. Corroboration of the present result is offered by Yerkes' finding that apes prefer blues and greens to yellows, oranges, and reds (Harlow, 1945), and the fact that innate color preferences have been reported in other vertebrates (Hess, 1956). Thus, our finding that squirrel monkeys prefer some colors to others should be taken into account in situations where colored stimuli are used.

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Conditional-outcome choice behavior in squirrel monkeys

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Six naive squirrel monkeys were given conditional-outcome choice training with two equally-often rewarded alternatives. One was a soluble two-choice color discrimination while the other was a pair of identically-colored stimuli. At regular intervals the monkeys were allowed to choose between them. Two Ss were trained on only one pair of problems, and one of these Ss displayed a temporary preference for the conditional-outcome alternative.

Will an S prefer an alternative where it can control reward, an alternative where reward is under E's control, or will there be no preference? Logan (1962) devised the conditional-outcome choice situation as a means of attacking this question. In a conditional-outcome choice situation an S is trained concurrently on two equally-often rewarded alternatives. One alternative (conditional) contains a contingency for obtaining reward and the other (nonconditional) does not. Every so often S is allowed to choose between alternatives. Logan applied this situation in seven studies using rats in double alleys and block-eight mazes and in four cases found preferences for one or the other of the alternatives. The preferences were not strong, and Logan attributed them to chance, to delay of reward, or to an artifact of his reward-matching procedure. The artifact was a lag effected by delivering nonconditional reward in one block of trials with the frequency that S had earned conditional reward in the previous block of trials. Logan concluded that "there is no preference between a conditional-outcome alternative and one with the same frequency of reward uncorrelated with performance" (Logan, 1962, pp. 475-476).

The present experiment attempted to determine whether this conclusion applied to primates in a situation designed to take advantage of the superiority of these animals to rats in ability to solve problems (Warren, 1965) and in responsiveness to visual stimuli. Thus, squirrel monkeys were tested in a situation where the conditional alternative was a two-choice discrimination (two differentiable stimuli) and the nonconditional alternative was an insoluble two-choice problem (two identical stimuli). Neither the conditional nor the nonconditional alternative was associated with a given side of the apparatus, and a new technique for matching nonconditional rewards to conditional performance was introduced. In addition, because one of Logan's studies suggested that a preference was likely to occur during the acquisition phase of a discrimination problem, some monkeys were allowed to solve only to a lax criterion before new problems were introduced.

Method

The apparatus has been described elsewhere (Green, Moore, & Sargent, 1966). Briefly, it consisted of a sheet-metal cube with a pair of display panels at one end. Opaque and transparent guillotine screens were used to cover the stimulus holes in the upper half of the display panels, but they did not cover the hole giving access to a delivery tray centered lower in each panel. The panels were white, the opaque screens were gray, and the remainder of the apparatus was black.

Eight naive adult squirrel monkeys were trained to press the stimulus panels and to receive reward from the delivery cups. Prior to experimental training all Ss were given a test for color preference (Green et al, 1966).

Experimental training was given each day according to any of a set of 10 42-trial sequences. The sequences specified the order presentation of the six daily choice trials and the three or nine trials between choices on which the Ss were forced to each alternative. The sequences were arranged such that each S each day responded an equal number of times to each problem and each side of the apparatus. Also denoted was the number of conditional trials (4 or 10) to be examined for purposes of matching nonconditional rewards to conditional performance. The noncorrection technique was used for all problems.

Nonconditional reward was matched to conditional performance by two methods. Logan's "frequency" procedure was used for one group of animals. A probabilistic procedure was used for a second group of animals wherein the most recent conditional performance was examined and a random device employed (a marble was drawn from an urn or a Lehigh Valley Model 1485 random generator was activated) to determine whether reward would be delivered on any given nonconditional trial.

Two males and two females were tested according to a successive-problem procedure wherein a new set of problems was introduced as soon as a criterion of 14 correct responses within 15 consecutive conditional trials was reached. The males were tested for 70 days and the females for 35 days; three Ss received reward matching by the probabilistic procedure and one by the frequency procedure. Two other males (Anton and Gustav) were trained for 50 days on a single set of problems and for an additional 20 days according to the successive-problem procedure; one of these Ss received reward matching by the probabilistic procedure and the other by the frequency procedure. Two additional females received 42 con-

ditional-problem trials each day for 20 days under the successive-problem procedure. These Ss served as controls for the possible interference with the development of observing responses (Stollnitz, 1965) effected by presentation of the nonconditional with the conditional problem.

Results

A problem was designated as genuinely preferred if it was chosen (a) on a least four of the six daily choice trials and (b) at least once when it appeared on the side of the apparatus opposite that preferred by S. Application of these criteria showed that genuine preferences occurred on 44 (15.4%) of the 286 experimental days and within these days on 229 (10.8%) of the 2117 choice trials.

The single-problem monkeys solved the conditional problem rapidly, and for the remainder of the 50 days on this problem combination the Ss followed the correct stimulus on the conditional alternative and position responded on the nonconditional. Anton displayed a preference on 53 choice trials, thus accounting for 23% of the genuine preferences of all Ss. The preference was for the conditional alternative, and it was displayed on seven of the first eight days of high-level conditional performance and on three later days. Under the successive-problem procedure, to which these Ss were switched on the 51st day, neither animal solved the new conditional problem. On one day, however, Gustav displayed a preference for the conditional alternative. Gustav's conditional performance on this day exceeded 60% correct.

The successive-problem monkeys displayed genuine preferences on 172 (75%) choice trials, but less than 40% of these preferences occurred at times when conditional performance exceeded 60% correct and fewer still occurred when the Ss were responding differentially on the two alternatives. The preferences of these monkeys appeared to be related to color in that the selected alternatives were found on 162 (94%) of these trials to contain stimuli which had been shown by a color preference test (Green et al, 1966) to be more preferred than the stimuli in the other alternatives.

Neither of the two control Ss solved problems more efficiently than the better experimental Ss. It thus appears that presentation of the nonconditional problem did not necessarily retard formation of observing responses appropriate to correct conditional responding.

No differential effect on choice behavior was noted for the frequency and probabilistic procedures for matching reward.

Discussion

Logan (1960) suggested that animals in any situation should respond in a manner consistent with maximum reward and minimum effort. Perhaps the most efficient way to respond in the present situation would have been to follow the correct stimulus on the conditional alternative and to position respond on the nonconditional. Given this (or some other) type of differential responding, it would be evident that the monkeys discriminated between alternatives. If it is argued that an S must discriminate between alternatives before meaningful choices between them can be made, then it becomes apparent that the results of only the two single-problem monkeys are relevant to the problem at hand. One of these Ss temporarily preferred the conditional alternative, where reward was under his control. In contrast, when the successive-problem Ss preferred an alternative they selected on the basis of preferred colors rather than reward control. It is apparent that the lax solution criterion minimized the number of choices allowed at times when these Ss were discriminating between alternatives. That is, an S no sooner attained high-level conditional performance and began responding differentially on the two alternatives than a new set of problems was introduced and the S had to learn anew which alternative contained the contingency.

It should be pointed out that rats in Logan's (1962) situations chose a problem prior to encountering the stimuli within the problems, whereas on choice trials in the present experiment the four stimuli of the two alternatives were presented simultaneously. Nevertheless, in light of the preference for the reward-control alternative shown by one of the single-problem monkeys, and the finding by Weir (1965) that children prefer predictable to nonpredictable reward, it is suggested that Logan's conclusion may not apply to primates.

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Drive and incentive combinations during acquisition, shift and extinction¹

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For 16 days, rats received 1 trial a day training in a straight runway with either 3 or 23 hr. of food deprivation (D) and .2gm or .8gm of food incentive (K). This training was followed by D and K shift for 32 days and 16 days of extinction. Significant differences were obtained for D and K; however, the D x K interaction was not significant. The D and K shifts suggest some stability of performance over time, and the D and K were related to rates of extinction.

The combination of drive and incentive has been subject to considerable research in light of Hull's (1952) and Spence's (1956) formulations (Black, 1965). The present study investigated the relation between two levels of drive, two levels of incentive, and the interaction between these variables, as well as the "temporary" nature of the drive and incentive shift and the rate of extinction.

Subjects

The Ss were 80 experimentally naive, male albino rats, approximately 90 days old at the beginning of the experiment.

Apparatus

The apparatus was a simple flat black, 60 in. straight runway box. The first 10 in. served as a starting box and was separated from the remainder of the box by a sliding door. A white food cup was placed 2 in. from the opposite end of the apparatus and a second sliding door was placed 16 in. in front of this food cup. Two infra-red photocells and timers were used, one cell 1/4 in. in front of the starting box and the other cell over the food cup. When the door of the starting box was raised it closed a circuit and activated one timer. The S's breaking the beam of the first cell activated a second timer, and the S in breaking the beam of the second cell over the food cup stopped both timers. Thus, the total, start box, and runway latencies were measured.

Procedure

For the first three days each S was handled by the Es for 3 min. per day. During this period the Ss had free access to food and water. The Ss were then divided on the basis of equal median weight into two groups, A and B, of 40 Ss each. The following five days Group A was placed on a 3 hr. food deprivation schedule (D₃) and Group B on a 23 hr. food deprivation (D₂₃). On the following two days, the deprivation was continued, but each S was allowed 5 min. of free exploration of the maze.

Groups A and B were then divided into subgroups (A₁ & A₂ and B₁ & B₂) of 20 Ss each. For 16 days

each S was given one trial a day training in the runway with A₁ receiving an incentive of .2 gm or (K₂), and A₂ an incentive of .8 gm (K₈), B₁ .2 gm, and B₂ .8 gm. The K was a single pellet of food weighing the specified amount. The following day each subgroup was again divided into groups of five Ss each for a total of 16 groups. Four of these groups served as controls, i.e., A_{1a} (D₃K₂) and the remaining 12 groups underwent either a shift of K, or D, or both, i.e., A_{1b} (D₃ K₈), A_{1c} (D₂₃ K₂), A_{1d} (D₂₃ K₈). For 32 days each S was given one trial a day under this new schedule. The last 16 days, the Ss ran one non-reinforced trial a day under the food deprivation schedule used during the shift. In all cases the total latency criterion of 2 min. was used as the maximum response time.

Results and Discussion

Total latencies for the last day of the acquisition period indicated that the large K groups ran significantly faster than the small K groups ($F=4.01$, $df=1/76$, $p<.05$). However, the greatest difference was obtained between the two measures of drive with Ss under the greater drive level running faster ($F=16.62$, $df=1/76$, $p<.001$). The interaction of K and D was found to be non-significant ($F<1.00$); thus there is no differential effect between the two variables. The data from the runway and start box latencies are compatible with the total latencies with the exception that there are no differences between the start box latencies for the K variable. These general results are consistent with those reported in the literature and support Spence's drive and incentive formulation.

At the end of the 32 days following the D and K shifts, the results from the total latencies revealed a yet greater significant difference between the drive levels than during the acquisition trials ($F=21.18$, $df=1/76$, $p<.0001$). This may be accounted for by the fact that the low drive groups at the end of the shift period were running significantly slower than at the end of the acquisition period and that the high drive groups were running at approximately the same speed. Non-significant differences were observed between the K levels ($F=1.62$, $df=1/76$, $p<.05$) and the drive and incentive interaction ($F<1.00$). These data suggest that the K-shift effects may be temporary, and that such temporary effects occur when the drive level is low. Both runway and start box latencies lead to the same general conclusion as the total latency data.

On the final trial of the extinction period, the total latencies signify a significant difference between the drive levels ($F=7.41$, $df=1/76$, $p<.05$). The latencies

for the low drive level increased but the greatest change occurred for the high drive groups. As with the shift data, no significant differences were obtained for the K variable ($F < 1.00$) nor for the interaction ($F < 1.00$). Other latency measures yield similar conclusions.

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Notes

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Probability learning in the goldfish:

I. Aversive reinforcement¹

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Two groups of goldfish were run 200 trials in a shuttlebox; consistently shocking one side for one group, and shocking one side 80% of the time and the opposite side 20% for the second group. The 100% group chose the nonshocked side with a 100% frequency at asymptote. The 80% group chose the least frequently shocked chamber with a frequency significantly lower than the 100% group, but significantly greater than 80%. Difficulties for several theories of probability learning are discussed.

The purpose of this experiment was to study the probability learning behavior of the goldfish with aversive reinforcement. The familiar mathematical learning models (Estes, 1950; Bush & Mosteller, 1955) predict that an organism will match the probability of occurrence of the positive event; i.e., in the case where an aversive stimulus such as shock occurs 20% of the time in the right-hand compartment of an aquatic shuttlebox, the fish should after a sufficiently large number of trials, choose that side on 80% of the trials. Behrend & Bitterman (1962), using positive reinforcement and a special correction method, were able to support the matching prediction with the African Mouth-breeder (*Tilapia macrocephala*), although they found that the fish maximized without the correction procedure. Based on these results Bitterman (1965) concludes that fish tend to probability match.

Method

Twenty goldfish, 1-1/2 to 2-1/2 in. long were used as Ss.

The apparatus was a Lafayette Aquatic Conditioning Apparatus. It consisted of a glass aquarium (6-1/2 x 3-1/2 x 3 in.) divided into two 3 x 3 x 3 in. compartments by a piece of opaque plastic with a 2 in. square doorway cut in the center. The right compartment's back and side walls were covered with black material, and the left compartment's back and side walls were covered with white material. The covering reduced distracting stimulation and served to differentiate the two compartments. The uncovered front glass allowed the E to observe the S's behavior. The floor of each compartment consisted of a stainless plate that functioned as an electrode. The other electrode for each side was a screenwire plate suspended just under the surface of the water. A control panel provided the E with the capability of choosing both the level of shock and the compartment shocked. A warning stimulus was provided by a 40-watt bulb in a spun aluminum hood suspended 8 in. above the center of the apparatus. The intertrial and interstimulus intervals were controlled by a Minarik rotary timer.

The Ss were divided into two groups of ten fish. Each S was placed in the apparatus and allowed to adapt for 5 min. After adaptation, 200 trials were administered with fixed intertrial interval of 6 sec. Each trial consisted of a 5-sec. "warning stimulus," followed immediately by a 1-sec. shock in one or the other compartment. The shock was 60 cps AC which was adjusted for each S during the first few trials to a level at which it elicited sudden motor movement, but was well below tetanizing levels. The range of shock levels was estimated between 5-15 volts. Care was taken to alternate the side of the apparatus in which the S was first placed, although there was no relationship between the side in which the S was placed and the side S was in during the first trial. All 200 trials were administered in one session. Five Ss were run with the black-right side punished on 100% of the trials, and five were run with the white-left side punished on 100% of the trials. This group is referred to as the "100-0 group."

The second group of 10 Ss, called the "80-20 group," was run in the same manner as the 100-0 group, except that five Ss were run with the black-right side punished on 80% of the trials and the white-left side punished on 20%. The percentages were reversed for the other five Ss. The series of left and right shocks was random with two constraints: (1) for every block of 10 trials there were two shocks on one side, and eight on the other; and (2) at least two trials had to intervene before the less frequent side was shocked again. The series was the same for all Ss.

The response scored was the side of the shuttlebox the S occupied at UCS onset.

The raw data from the 80-20 group were submitted to a computer program which computed the least squares solution to the prediction equation derived from Estes' (1950) model (E-model). This least squares solution was then subjected to a Monte Carlo program which in turn generated simulated data for 10 Ss over 200 trials. This simulated group of Ss will be referred to as the 80-20MC group. For a general discussion of the Monte Carlo technique see Bush & Mosteller (1955).

Results

The E-model learning rate for the 80-20 group (assuming side preferences were balanced out by the experimental procedure) was determined to be .028. The theory predicted 30% of the variance for this group. The raw data for each S in all three groups were converted into proportions of each response taken over 20 blocks of 10 trials each. The last five blocks of proportions were then analyzed by the Kruskal-Wallis two-way analysis by ranks. In addition, the 100-0 and

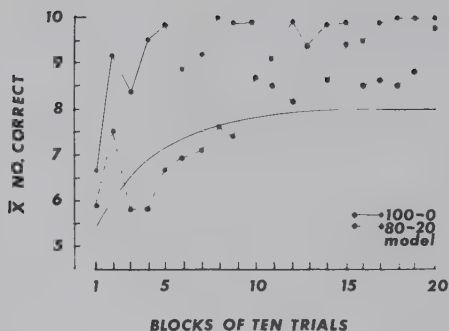


Fig. 1. Mean number of responses in the less frequently shocked compartment (correct responses) over trial blocks.

80-20 groups, and the 80-20 and 80-20MC groups were compared using the Mann-Whitney U-test. These non-parametric tests were chosen in favor of parametric tests because of the larger number of proportions equal to unity for the 100-0 group. Figure 1 presents these means and the stochastic learning model's least squares prediction.

The Kruskal-Wallis test indicated the three groups differ significantly for the last 50 trials ($p < .001$). The two Mann-Whitney tests indicate the 80-20 group was significantly different from the 100-0 group ($p < .01$), and from the 80-20MC group ($p < .01$). Again, these tests pertain to the last 50 trials.

Discussion

The statistical analysis indicates that the group of goldfish run under the 80-20 regimen neither matched nor maximized. This result is inconsistent with the E-model since it predicts probability matching (Estes, 1957). This prediction is independent of (1) all characteristics of the Ss; and (2) all aspects of the experimental situation excepting the frequency of shock.

Bush and Mosteller's model (BM-model), on the other hand, is capable of predicting our results, even though the most common assumptions (used to simplify the mathematics) developed predictions exactly the same as those of the E-model.² An important and routinely used simplifying assumption implies that shock and no-shock have "equal but opposite" effects on the learning process (Bush & Mosteller, 1955, p. 119). As these authors point out (1955, p. 288) this assumption does not appear intuitively reasonable and they show that it must be rejected when matching is not found.

For the 80-20 group, therefore, the effect of shock was not "equal but opposite" to the effect of no-shock. Unfortunately it is difficult to obtain a mathematically satisfactory estimate of the effects of shock and no-shock (Bush & Mosteller, 1955, p. 288) but it is possible to estimate the ratio of these two effects. This was done by using a BM-model formula (1955, p. 289) and assuming that the last 50 trials were asymptotic for this experiment. The procedure indicated that the behavioral effect of shock was 1.11 times greater than that for no-shock.

Using this ratio the BM-model can predict our results more accurately than the E-model; but note that the asset of more accurate prediction is balanced by the liability of having to estimate an extra parameter. For the E-model two parameters must be estimated from the data: The initial side preference of the Ss (if any); and the overall learning rate. For the BM-model three parameters must be estimated: The side preferences; the learning rate following shock; and the learning rate following no-shock. The extra parameter is necessary to accurately predict our results.

In addition, our results appear to restrict the generality of Bitterman's conclusion that fish probability match. With the aversive stimulus of shock, and without correction, our fish neither matched nor maximized; therefore, our results are not in conflict with the phyletic hierarchy postulated by Bitterman (1965). However, we must agree with Bitterman that his rat-fish dichotomy is strained by the data, and we feel that the addition of our data increases the strain.

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Notes

1. The assistance of the University of Southern California Computer Sciences Laboratory and the Honeywell Corporation in providing computing time is gratefully acknowledged. The computer programs used in this study are available from the first author upon request.
2. Technically the E-model is the same as the E-controlled, equal-alpha, zero-unity absorbing state BM-model. The BM-model referred to is the E-S-controlled, equal-alpha, zero-unity absorbing state BM-model. The rejected assumption is the equal-alpha assumption. Both the E-model and the BM-model are sets in the field of BM-models.

Amnesic effects of ether and electroconvulsive shock in mice¹

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Mice were given a painful foot-shock upon stepping through a small hole into a dark chamber. Different groups were administered either ECS or 40 sec. or 70 sec. of ether following the learning trial. On a test trial 22 hr. later the 70 sec. etherization and ECS groups showed no memory for the foot-shock while the shocked but untreated control Ss evidenced good retention. The results support a consolidation disruption interpretation of retrograde amnesia.

Several investigations (Abt, Essman, & Jarvik, 1961; Essman & Jarvik, 1961; Pearlman, Sharpless, & Jarvik, 1961) have indicated that ether anesthesia, induced shortly after a single shock-avoidance trial interferes with the memory for the experience. However, one of the present authors (Herz, 1962) failed to find retrograde amnesia utilizing the procedure and the duration of anesthesia used by Abt, Essman, & Jarvik (1961). However, amnesic effects were suggested by the results of a group etherized for a longer period of time.

The present investigation was undertaken to assess the importance of anesthesia duration in the production of retrograde amnesia and to directly compare ether- and electroconvulsive shock-produced retrograde amnesia.

Method

The Ss were 75 male and female Swiss-Webster mice obtained from the colony maintained at U.S.C. They were approximately 6 weeks of age and all were naive.

A "step-through" avoidance learning apparatus (Essman & Alpern, 1964) was used in the study. It consisted of a 6-1/4 cm x 2-1/4 cm metal platform extending horizontally from the lower edge of a 3-1/4 cm diameter hole. The hole served as the entrance to a darkened chamber, the metal floor of which was 5 mm below the level of the platform. A 60 w bulb in a reflector 30 cm above the platform was illuminated during the experimental sessions. The apparatus was placed at the edge of a laboratory table so that the distance between the platform and the floor of the room was approximately one meter. The room temperature was 30-31°C.

Ss were assigned to seven groups of nine each (additional Ss were utilized to replace those that failed to recover from ECS or ether): (1) a shock control group (S) which received foot-shock on stepping from platform to chamber on Day 1 and received no further treatment, (2) a group which received foot-shock and was then immediately etherized for 40 sec. (SE₄₀), (3) a group treated as group (SE₄₀) but etherized for 70 sec. (SE₇₀), (4) a group receiving foot-shock followed immediately by ECS (SECS), (5) a group receiving no foot-shock on stepping through the hole (N), (6) a group

receiving 70 sec. of ether following a non-shocked step-through (NE₇₀), and (7) another non-shocked group administered ECS immediately following a step-through (NECS).

Ss were caged according to groups and had free access to food and water. On the first experimental day each S was lifted by the tail and placed on the platform with the head facing the hole. The latency from platform placement to placement of one paw on the chamber floor was recorded. Ss with initial step-through latencies greater than 10 sec. were discarded and replaced with new Ss (one S in group SECS and one in group N). Ss in groups S, SE₄₀, SE₇₀, and SECS received a 3 ma foot-shock (from a constant current source) when one foot made contact with the chamber floor, thus completing a circuit between the platform and the chamber floor. Ss in the remaining groups received no foot-shock.

Ss in the ether groups, SE₄₀, SE₇₀, and NE₇₀, were removed from the chamber after stepping through and immediately placed in a 1000 cc container which contained gauze pads saturated with ether. Additional ether was added between animals so that the gauze remained saturated. With this procedure Ss lost the righting reflex within 20-30 sec. Ss were kept in the container for either 40 or 70 sec., depending upon the group to which they were assigned. (Six Ss failed to recover from 70 sec. of ether.)

Ear clip electrodes (with electrode paste) were attached to the animals in the ECS groups immediately following their removal from the chamber. ECS was induced by passing 120 v (r.m.s.), 60 cycle sine wave, 15-18 ma, through the animal for 200 msec. Tonic-clonic convulsions were produced in all Ss. (Four animals failed to recover from ECS treatment.) The median delay from foot-shock to application of ECS was 10 sec.

Twenty-two hours after the first experimental session all Ss were again placed on the platform and the step-through latency recorded. Animals that remained on the platform for more than 30 sec. without stepping through the hole were removed and assigned a latency of 30 sec. for the trial. None of the Ss received foot-shock on the test trial day.

Results

Median step-through latencies for Day 1 and Day 2 are presented for all groups in Fig. 1. Overall analyses of variance (Kruskal-Wallis) indicated no significant differences among groups for Day 1 and significant differences among groups ($H = 24.79$, $p < .001$) for Day 1-Day 2

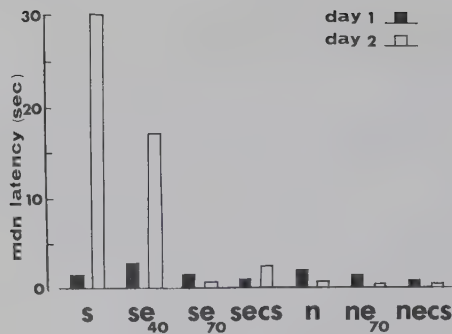


Fig. 1. Median Day 1 and Day 2 step-through latencies (in sec.) for shock control group (s), shocked 40 sec. ether group (se₄₀), shocked 70 sec. ether group (se₇₀), shocked ECS group (secs), non-shocked control group (n), non-shocked 70 sec. ether group (ne₇₀), and non-shocked ECS group (necs).

difference scores. There was no significant difference among groups SE₇₀, SECS, N, NE₇₀, and NECS for Day 2 latencies. Mann-Whitney U tests performed between the shock control group (S) and the above 5 groups combined, and between group SE₄₀ and the above 5 groups both yielded values significant beyond the .001 level. Mann-Whitney comparison of groups S and SE₄₀ resulted in $H = 24$ ($p < .10$).²

Discussion

The results clearly indicate that the foot-shock was sufficient to produce one-trial avoidance learning in the shock control animals (S). Approximately 60% of the animals in that group remained on the platform for the full 30 sec. In addition, both ECS and 70 sec. ether produced clear retrograde amnesia as evidenced by the absence of a difference between these two groups and the non-shocked control groups. Further support for an amnesic interpretation of these results is offered by the finding that nearly 60% of the shock-70 sec. ether Ss and 70% of the shock-ECS animals had unchanged or decreased latencies on the Day 2 test trial whereas all of the Ss in the shock control group showed increased latencies on this trial. The equivocal results with the shock-40 sec. ether group supports the contention that duration of etherization is one of the important variables in ether-produced amnesia. Although 70 sec. of anesthesia is sufficient to induce an amnesic effect, 40 sec. is not. The comparison between the 70 sec. ether and ECS experimental groups suggests that the two methods have a similar effect on the memory for the foot-shock.

These results, when considered in conjunction with the findings of Herz (1962) and Alpern & Kimble (in press) suggest that ether-produced amnesia is determined, to some degree, by the interaction of temperature and duration of anesthesia. Jarvik (1964) has also found temperature to be a critical variable in the production

of ether amnesia. Herz (1962) found that 120 sec. of etherization gave results suggestive of amnesia at 22°C, while Alpern & Kimble (in press) found that 15 sec. of ether was sufficient to produce clear amnesic effects with potentiated ether (the etherization chamber was heated to 38°C). The present study indicated that clear retrograde amnesia can be produced with intermediate temperature (31°C) and duration (70 sec.).

The results of the present investigation indicate that both ether and ECS, when administered immediately following a painful foot-shock, produce relatively complete retrograde amnesia for that event. Although alternative explanations for the retrograde amnesic effect have been offered (e.g., the conditioned inhibition hypothesis of Lewis & Maher, 1965) the present results appear to support a consolidation theory interpretation since both amnesic agents were administered outside of the experimental situation. The resulting conditioned inhibition or relaxation, if any, would therefore be conditioned to the place of treatment rather than to the experimental apparatus, a point raised in a recent reply to Lewis & Maher (1965) by McGaugh & Petrinovich (in press).

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Notes

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2. A replication of this study was carried out with an additional 63 mice obtained from a commercial supplier. These animals were older males (12 weeks) and were much more active and very difficult to handle. With the exception of the 40 sec. ether group, which in the replication did not differ from the shocked 70 sec. ether and ECS groups, the same pattern of results and significant differences emerged. It should also be noted that the Day 1 and Day 2 latencies were significantly shorter than in the reported study.

Influence of collateral water drinking on bar pressing under complex reinforcement contingencies¹

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Rats were run on 2-link chained schedules. The first link was always FI 2 min.; the second link was either FR 10; DRL 10 sec.; or Concurrent FR 10 DRL 10 sec. All responding was on a single bar. Responding in the first link was reinforced by onset of the second-link stimulus, and in the second link by 45 mg Noyes food pellets. When the ad lib water bottle was removed from the chamber, rats on Chain FI FR or Chain FI DRL showed an increase in FI bar presses but no change in second-link behavior; rats on Chain FI Concurrent FR DRL showed the major change in the second link; DRL behavior was almost wholly replaced by FR behavior.

Clark (1962) noted that water drinking prevented typical performance on a VI food schedule. We extend Clark's observations by showing the effect of allowing or preventing drinking on some complex performances.

Method

Adult, albino rats, two males and two females, were kept at 80% of ad lib weight by food, but not water, deprivation. One of each sex was assigned to Chain FI 2 min. Concurrent FR 10 DRL 10 sec.; a male to Chain FI 2 min. FR 10; and a female to Chain FI 2 min. DRL 10 sec. First links were marked by flashing of a cue lamp; second links by steady illumination of the lamp. A cycle of the chain consisted of one completion of the FI 2 min. contingency followed by 11 food reinforcements in the second link. Sessions for males were 20 cycles long; for the smaller females, 14 cycles.

The conditioning chamber contained only one bar, mounted centrally on the front wall; the cue lamp above it; the water bottle to the right of it; and the food cup to the left of it. All but the front wall and floor were made of transparent lucite. The chamber was housed in a darkened, sound-resistant room containing white masking noise.

All schedule components were standard except for the Concurrent FR DRL. During this schedule, the FR and DRL contingencies held simultaneously. Every bar press spaced 10 sec. or more from the last was reinforced via the DRL contingency; every 10th press spaced less than 10 sec. from the last was reinforced via the FR contingency. Every reinforcement reset both contingencies.

The rats were pretrained on smaller FI, FR, and DRL requirements before the present values were put into effect. The data reported here were from the 18th and 19th days under the present conditions. On the 18th day

the water bottle was removed before sessions began; on the 19th day, it was replaced.

Results

Figure 1 shows the results of removing water. Day 19, rather than 17, is offered as the control (with water) day because of recording difficulties on day 17.

Chain FI 2 min. Concurrent FR 10 DRL 10 sec.: Rat RF. When water was present (day 19) FI pressing was at a rate barely sufficient to advance the chain from the first to the second link; there was no FI "scallop-ing." RF took its food entirely via the FR contingency in the first 2 cycles of day 19 and entirely via the DRL contingency in the remaining cycles. Removing water (day 18) increased the rate and curvature of FI responding, and transformed the second-link performance to mainly FR behavior.

Rat RM. Control performance (day 19) included a large amount of FI pressing with marked scalloping; and an irregular alternation of DRL and FR behavior in the second link. Removing water (day 18) increased FI responding but, as in RF, had its main effect on second-link behavior, which was transformed to mainly FR behavior.

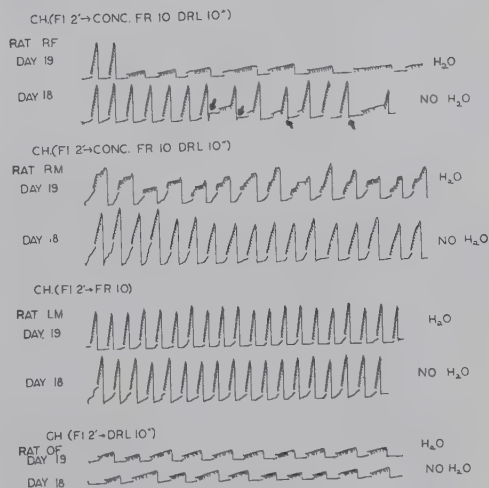


Fig. 1. Cumulative bar presses for the first 60 min. of day 18 (without water) and 19 (with water). The pen reset to baseline after every 11 food reinforcements, and was offset slightly downward and to the right during first (FI 2 min.) links. Momentary downward pen deflections during second links mark food arrivals.

Chain FI 2 min. FR 10: Rat LM. Control performance (day 19) showed very shallow FI scallops and typically high and steady FR rates. Removing water (day 18) increased the steepness of the FI scallops but had no apparent effect on FR behavior.

Chain FI 2 min. DRL 10 sec.: Rat OF. Control performance (day 19) showed a very low FI rate, with virtually no scalloping. DRL performance was at the low and steady rate typical of this schedule. Removing water (day 18) led to a very slight increase in the number of FI responses, but still without scalloping. There was no evident effect on DRL behavior.

Discussion

This experiment antedated most of those on psychogenic polydipsia earlier reported from this laboratory (e.g., Deadwyler & Segal, 1965) and records of water drinking were not made. We will reconstruct the control pattern of drinking by inference from the effects of withholding water, together with recollections of some visual observations.

1. *The conditions for drinking.* Drinking seemed to occur whenever the prevailing schedule included interval contingencies. Thus, we infer that all rats drank during FI links, with a consequent great or small depression of bar pressing, for all rats pressed more when drinking was prevented. Rats drank during Concurrent FR DRL, again with a depression of pressing, for both rats on this schedule pressed much faster when drinking was prevented. In contrast, we infer that drinking did not occur during the FR schedule, for preventing drinking did not increase FR rate.

2. *The role of drinking in timing.* Neither did preventing drinking increase DRL response rate, and yet direct observation showed that the rat (OF) did drink between presses when water was available. The explanation of this anomaly is very likely the DRL contingency. The rat had never been reinforced for any but low-rate pressing; so, unlike the other three rats, it had no alternative but to go on pressing at low rate, even when water was absent.

3. *Rat RM: direct observations.* The arrival of the first food pellet of a cycle generally led to drinking. The rat visited first the food cup, and ate, and then the water bottle, and drank, and then the bar, and pressed. If this sole press produced another pellet, the sequence repeated. If it did not, the rat's posture changed: it grabbed the bar in both paws, one above and one below,

and jiggled it rapidly until a pellet arrived. Thus, the contingencies appear to have generated two response sequences in this rat, each under discriminative control. The basic sequence was one press-eat-drink-one press-eat-drink... The second, conditionally inserted into the basic sequence whenever a single press failed to produce food, was vigorous two-pawed jiggling of the bar.

4. *Interactions of drinking and bar pressing.* Only where the reinforcement contingencies provided a wholly different option, viz., in the concurrent schedule, did the prevention of water drinking cause a dramatic change in the character of bar pressing. The effect on FI performance of preventing drinking was to cause more nearly typical FI behavior to appear. The effect on simple FR or DRL performances was nil. Although the performances were more or less different depending on whether drinking was allowed or not, it would seem a mistake to conclude that the "dry" performance was a truer reflection of the reinforcement contingencies than the "wet" one, or that drinking competed with "normal" bar pressing. Rather, it seems that collateral behavior such as drinking is as much a normal outcome of certain reinforcement contingencies as are the familiar bar-pressing patterns.

5. *A note on inductive effects.* FI response rate seemed to reflect whatever rate was reinforced in the second, food link. Thus, the DRL schedule conditioned low rate, and so OF emitted a low rate in the FI link, too. The FR schedule conditioned high rate, and so LM emitted a relatively high rate in the FI link. The concurrent schedule generated a predominantly low rate in RF and so its FI rate was low; it generated a much higher rate in RM and so its FI rate was much higher. These inductive effects, moreover, were independent of water drinking.

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Notes

- 1. Supported by NSF G 18132, NSF GB 1605, and NIMH 8505.
- 2. On leave at the Royal College of Surgeons of England. Send reprint requests to Mr. David Oden, Department of Psychology, San Diego State College, San Diego, California, 92115.

Discrimination of area differences by the harbor seal¹

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An earlier investigation of the underwater size discrimination abilities of the California sea lion (*Zalophus californianus*) was replicated with Harbor seals (*Phoca vitulina*). Performance was equivalent even though there was a marked difference in test behavior and general activity level.

Previous work by Schusterman, Kellogg, & Rice (1965) indicates that the California sea lion (*Zalophus californianus*) is capable of reasonably good size discrimination under water. This study is a replication of the size discrimination work with the Harbor seal (*Phoca vitulina*). It should be noted that while both species belong to the Order Pinnipedia, *Phoca* belongs to the Super-family Phocoidea and *Zalophus* to the Super-family Otarioidea, so that they are distinctly different animals anatomically.

Subjects

The Ss were one male (Runt) and one female (Goldie) Harbor seal (*Phoca vitulina*), approximately eight months old at the beginning of the experiment.

Apparatus

The experiment was conducted in a 13,000 gallon, fresh water, circular plastic tank modified (Fig. 1) to provide an alley 19 ft. long and 7 ft. wide. One end of the alley contained a ramp (A) to allow the animal to enter and leave the water. The other end of the alley

contained a frame and pulley system for presenting two visual stimuli simultaneously (B). The stimuli, flat discs of .050 aluminum painted flat black, were separated by an 18-in. plywood divider (C) which allowed the Ss to visually inspect both targets up to a minimum of 18 in. (choice point). Both the divider and the field behind the stimuli were painted flat white. The experimenter (E) sat behind a plywood screen (D) which shielded the presentation apparatus from the S until the targets were lowered into the water. The stimuli centers were 2 ft. below the surface of the water when in the presentation position. Water in the tank was continuously filtered through a diatomaceous earth filter which was recharged daily in order to maintain clarity.

Procedure

The seals were given preliminary training on land with a hand-held black square target until a pressing response was established and then were taken into the testing tank where further training established the following test behavior sequence: (1) the animal stationed itself at the entrance ramp (A) with its head out of water; (2) when E presented the stimuli, the noise from the frame and pulley system signaled the animal to swim underwater toward the stimuli; (3) S chose the right or left stimulus disc from a minimum distance of 18 in. and pressed the selected stimulus with his snout. The position of the stimulus was an irrelevant cue throughout this experiment. The stimulus display was withdrawn immediately following S's indicator response, and correct responses were reinforced with a small piece of cut herring (*Clupea pallasii*) which came from the animals's daily ration. The remainder of the ration was given to the animal immediately after it left the testing tank.

In order to determine whether a size preference already existed for the Ss, two discs differing in area by a ratio of 6.72:1 were presented simultaneously for 20 trials. The position of the stimuli was randomly alternated from right to left and responses to either target were reinforced. Runt showed a preference for the larger ($p < .05$) and Goldie for the smaller ($p < .001$) stimulus. An additional 50 training trials were run which called for reinforcement only when the preferred target was pressed. This served to firmly establish an animal's response to the appropriate stimulus size relationship.

The preliminary training sessions were designed to establish a starting point in the original series of size comparisons which had been used with the California sea lion (Schusterman et al, 1965). That point was

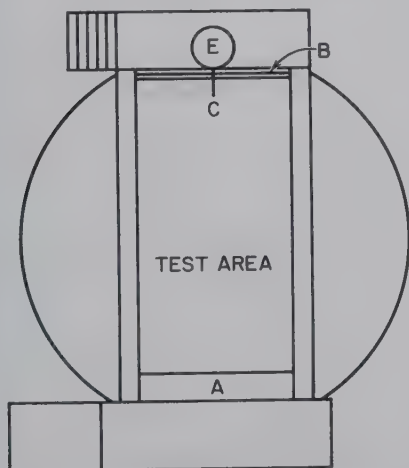


Fig. 1. Diagram of the test area (19 ft. x 7 ft. x 4 ft.), entrance ramp (A), visual stimulus presentation apparatus (B), choice point (C) 18-in. in front of visual stimuli, and experimenter's (E) position behind a plywood screen.

selected on the basis of the smallest area ratio which could be correctly responded to on 95 out of 100 trials. In order to maximize performance, training sessions were run with each of the stimulus pairs to allow experience with this kind of visual discrimination problem. The Ss were tested with discs that had area ratios of 2.59:1, 1.61:1, 1.27:1, 1.13:1, 1.06:1, and 1.03:1. The first three of these ratios were tested singly until the animals reached criterion. Beginning with the third ratio, 1.27:1, a test session included one easy and one or more difficult discriminations, in

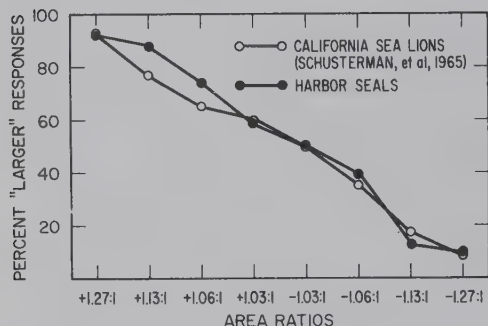


Fig. 2. A comparison of the ability of Harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) to discriminate small differences in the area of flat black discs. Percent "larger" responses refers to discrimination of the relative size of the variable stimulus.

order to reduce the level of frustration resulting from non-reinforced trials.

The threshold data are based on all trials run after a starting point was determined. This amounted to 50 trials per day for 20 days.

Results and Discussion

Figure 2 presents a comparison between the mean Harbor seal performance and that of the California sea lion as obtained by Schusterman et al (1965). Inspection of the curves indicates that despite the diverse structural and behavioral adaptations of these two pinniped forms, the ability to perceive and respond correctly to small differences in surface area is equivalent.

The Harbor seal is a wary animal that generally avoids contact with humans or other animals. We found that though they were quick to learn the test procedure, they sometimes performed erratically. Generally, they were slow and deliberate in approaching the stimuli, and would often ignore the food reward while continuing to follow the test procedure. Food deprivation was not effective in reducing the frequency of non-test-oriented behavior.

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Schusterman, R. J., Kellogg, W. N., & Rice, C. E. Underwater visual discrimination by the California sea lion. *Science*, 1965, 147, 1594-1596.

Note

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Appetitive thresholds of the hypothalamic "feeding area" self-determined in the rat

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Increasing intensities of electrical stimulation were delivered to the "feeding area" of the lateral hypothalamus of unrestrained rats. The animals could lick a tube to obtain milk or water. Licking the tube also operated a drinkometer which reduced the intensity of the brain stimulation. Thresholds of centrally-elicited "hunger" and "thirst" were thereby continuously estimated. Performance depended upon the availability of food or water.

Electrical stimulation of the "feeding area" of the lateral hypothalamus will cause a satiated animal to eat or to drink (Andersson & McCann, 1955; Larsson, 1954). Moreover, electrical stimulation of this area will motivate satiated animals to perform old habits instrumental in obtaining food or water (Andersson & Wyrwicka, 1957; Miller, 1957), or even to learn new habits instrumental in obtaining food (Mendelson & Chorover, 1965). However, in these and all related studies, the intensity of the electrical brain stimulus was fixed by the experimenter. Consequently, two basic questions in this area remain uninvestigated. Can the intensity of stimulation delivered to the "feeding area" be made quantitatively dependent on the animal's behavior, as in a "titration" self-adjustment situation? Will such "titration" depend upon the procurement of food and water, or merely upon the fractional reductions of the intensity of the brain stimulus as occurs in the case of ambivalent brain areas (cf. Poschel & Ninteman, 1965)?

Method

Monopolar electrodes were implanted in the "feeding area" of the lateral hypothalamus of 20 adult male albino rats. The electrodes were made of 30-gauge platinum wire, with 0.5 mm at the tip bared of insulation. About 14 days after surgery, the animals were given preliminary tests for stimulus-bound feeding and drinking reactions. In these tests the experimenter slowly raised the intensity of the electrical brain stimulus, while food pellets and a water bottle were freely available to the animal. About seven days later these tests were repeated. Nine successfully implanted

rats were found: six which ate, two which drank, and one which both ate and drank, when stimulated.

The titration tests were conducted in a chamber equipped with a metal drinking tube and drinkometer. The drinkometer operated through a circuit breaker which interrupted the circuit six times per sec., the approximate rate at which rats lick. This arrangement assured pulsed signals from the circuit even if the rats maintained continuous contact with the tube while licking. At the start of each test, a rat was placed into the chamber and allowed to satiate itself on milk or water from the drinking tube. Then electrical stimulation (sine wave, 60 cps) was continuously applied to the rat's electrode, starting at a low intensity. Every 1 min. the current intensity was raised one step by advancing a two-way stepping relay. If no licking of the tube occurred, the maximum stimulus was reached in 25 approximately equal steps. Every 33 licks, however, reduced the stimulus intensity by one step. Thus, the intensity of the brain stimulus was regulated solely by the rat's contact with the drinking tube. The stimulus levels maintained were recorded graphically by a two-way recorder.

Each animal received at least five titration tests, at least 40 min. long, usually seven days apart. The drinkometer bottle contained undiluted Carnation evaporated milk for the six rats which ate food in the preliminary tests, while tap water was used with the three rats which drank water. However, on one occasion, usually during a S's last test, the drinkometer bottle was empty. (An empty bottle did not hinder the operation of the drinkometer.) This test was terminated when the brain stimulus reached maximum intensity, or when the rat showed agitation incompatible with licking. Ultimately, electrode placements were confirmed histologically.

Results

Graphic records from a representative S, run on water, are presented in Fig. 1. Figure 1A shows the programmed rate of increase of the brain stimulus if

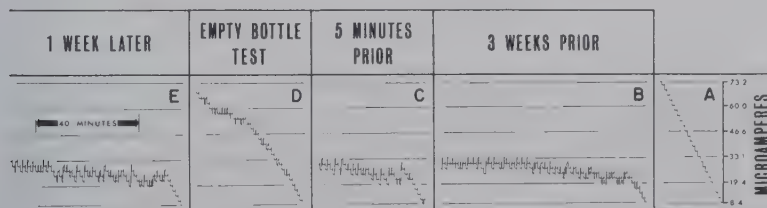


Fig. 1. Appetitive titration records of rat 1, run on water. Records read from right to left.

Table 1. Maximum Intensity of Stimulation Rats
"Tolerated" with and without Incentive Present

Rat	Type of incentive	Incentive present (μ a)	Empty bottle (μ a)
1	water	33.1	70.4
2	water	21.4	60.4
3	water	17.8	42.8
4	milk	21.4	62.7
5	milk	30.3	73.2
6	milk	30.3	73.2
7	milk	23.8	62.7
8	milk	22.4	73.2
9	milk	22.4	73.2

Note — Maximum intensity possible was 73.2 μ a.

no drinking occurred. Figure 1B shows the rat's behavior in the fourth titration session. The record shows low variability and a well-defined threshold, although there is a slight increase in threshold during the first half of the test; thereafter, the threshold undergoes no further change despite the lengthy session. This threshold is recoverable from week to week as indicated by Fig. 1C, which shows the seventh titration session. Figure 1D shows the effect resulting when the drinkometer bottle is empty of water, 5 min. after the preceding test. The record clearly indicates that the incentive is necessary for titration. Thus, this behavior is not reinforced primarily by the fractional reductions of stimulus intensity produced by licking, nor by the act of licking per se, but rather by the sensory stimuli of water. Figure 1E shows that seven days later the rat's baseline is again attainable with water.

Data from all Ss showing the effect of an empty drinkometer bottle are presented in Table 1. Listed is the incentive normally used with each animal, and the peak intensity of stimulation each animal allowed the stepper to reach with the incentive present, and then

absent. The data of the "incentive present" condition are from the tests run most recently prior to the empty bottle tests. Equal time was sampled under the two conditions by equating each pair of titration records on the basis of the length of the empty bottle test. The indicated difference between the two conditions is highly significant ($t=15.92$, $df=8$, $p<.001$).

Discussion

The present type of titration behavior depends upon the procurement of food or water, which clearly shows that the resulting thresholds pertain to the activation of appetitive neural systems. Stimulation of the hypothalamic "feeding area" seems to elicit a central process which an animal discriminates accurately, much like a sensory process. The results support the theoretical notion that this system of the brain subserves the drive-stimulus (or sensory) aspects of hunger and thirst, rather than mere motor systems for feeding and drinking.

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Predictability and number of pairings in Pavlovian fear conditioning¹

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Three groups of dogs were Sidman avoidance trained. They then received different kinds of Pavlovian fear conditioning. For one group CSs and USs occurred randomly and independently; for a second group, CSs predicted the occurrence of USs; for a third group, CSs predicted the absence of the USs. The CSs were subsequently presented while S performed the avoidance response. CSs which had predicted the occurrence or the absence of USs produced, respectively, increases and decreases in avoidance rate. For the group with random CSs and USs in conditioning, the CS had no effect upon avoidance.

Traditional conceptions of Pavlovian conditioning have emphasized the pairing of CS and US as the essential condition for the development of a CR. As long as the CS and US occur in temporal contiguity, the conditions for Pavlovian conditioning are assumed to be met. In contrast, another view of Pavlovian conditioning argues that conditioning depends upon the degree to which the CS allows S to predict the occurrence of the US. If the CS is followed by a change in the probability of the US, Pavlovian conditioning will occur. If the CS forecasts an increased likelihood of the US, excitatory conditioning will occur; if the CS forecasts a decreased likelihood of the US, the CS will take on inhibitory properties. According to this view, the number of CS-US pairings may be irrelevant to the development of a CR if the CS does not predict a change in the probability of occurrence of the US.

The experiment reported here explores the fruitfulness of this second approach to Pavlovian fear conditioning. Three groups of dogs received different kinds of Pavlovian conditioning. For one group, CSs and USs occurred randomly and independently in such a way that CS occurrences provided no information about US occurrences. In a second group, CS occurrences were followed by an increase in the probability of US occurrences; however, Ss in this group received the same number of CS-US pairings as did Ss in the first group. For a third group, CS occurrences predicted the absence of USs. These CSs were there presented while S performed a previously trained avoidance response. Increases in the rate of avoidance responding produced by CSs were taken as evidence for excitatory fear conditioning and decreases were taken as indicating inhibition of fear. Such changes in rate of avoidance responding have been shown by Rescorla & LoLordo (1965) to be a sensitive index of the level of conditioned fear.

Method

Ss were 18 mongrel dogs, individually housed and maintained on ad lib food and water throughout the

experiment. The apparatus was a two-compartment dog shuttlebox described in detail by Solomon & Wynne (1953). The two compartments were separated by a barrier of adjustable height and by a drop gate which, when lowered, prevented S from crossing from one compartment into the other. The floor was composed of stainless steel grids which could be electrified through a scrambler. Speakers, mounted above the hardware-cloth ceiling, provided a continuous white noise background and permitted the presentation of tonal stimuli.

The training procedure was similar to that described by Rescorla & LoLordo (1965). Each S was trained to jump the barrier, separating the two sides of the shuttlebox, to avoid electric shock. Brief shocks, 0.25 sec., were programmed on a Sidman avoidance schedule; the shock-shock interval was 10 sec. and the response-shock interval was 30 sec. The Ss received three initial days of avoidance training. On the first day the barrier height was 9 in. and the shock level 6 ma; on all subsequent days, the barrier height was 15 in. and the shock set at 8 ma.

Beginning with the fourth experimental day, S was confined to one-half of the shuttlebox and given Pavlovian fear conditioning. For the six dogs in Group R (random), 24, 5-sec., 3 ma shocks were programmed on a variable interval schedule with a mean of 2.5 min. Twenty-four, 5-sec., 400 cps tones were independently programmed randomly throughout the session in such a way that a tone onset was equiprobable at any time in the session. This was accomplished by a VI timer and a series of tapes. The six dogs in Group P (positive prediction) received a treatment identical to that of Group R except that they received only those shocks which were programmed to occur during the 30 sec. following each tone onset. The six dogs in Group N (negative prediction) received a treatment identical to that of Group R except that they received only those shocks which were not programmed to occur within 30 sec. after a tone onset. The treatments for Groups P and N were accomplished by having each CS onset reset a 30 sec. timer through which the pre-programmed shocks were gated. Thus, for Group P, CS occurrences predicted US occurrences; and for Group N, CS occurrences predicted absence of USs.

Pavlovian conditioning and Sidman avoidance training days were then alternated until S had received a total of seven avoidance and five conditioning sessions. On day 13 a single test session was given. During this session, S performed the avoidance response with the Sidman schedule remaining in effect. In addition, 24, 5-sec., 400 cps tones were superimposed upon the avoidance behavior with a mean intertrial interval of 2.5 min.

Changes in the rate of avoidance induced by these CSs were used as an index of the conditioned excitatory and inhibitory effects of the tones.

Results

The Sidman avoidance response was rapidly acquired by most animals and after several sessions all Ss were reliable responders. Figure 1 shows the results of the test session. Plotted in this figure are the mean number of responses per 5-sec. period of time over successive 5-sec. periods. Prior to the occurrence of a CS, all groups responded at approximately the same rate. However, the occurrence of a CS led to markedly different results in the three groups. For Group P, CS onset produced an abrupt increase in response rate followed by a return to base rate. The rate increase was confined to the first few 5-sec. periods following CS onset. In contrast, the CS produced a sharp decrease in rate in Group N. Again the rate change was maximal immediately following CS onset. For Group R, the occurrence of a CS produced very little effect.

Comparisons among the groups were made with the help of suppression ratios. These ratios are of the form $A/(A+B)$ where B is the mean rate in the 30 sec. prior to CS onset and A is the rate for the period on which the two groups are to be compared. Using this measure, the rate increase during the CS was reliably greater for Group P than for Group R ($U=0$; $p < .01$). Group R, in turn, responded more frequently during CS than did Group N ($U=0$; $p < .01$). Similar conclusions result if the groups are compared on the rate during the entire 30 sec. following CS onset.

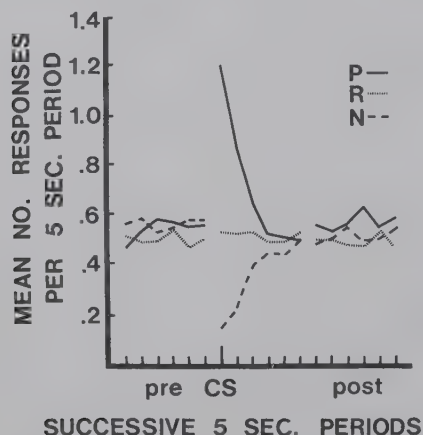


Fig. 1. Mean number of responses per 5-sec. period in successive periods prior to CS onset, during the CS and the subsequent 25 sec. of differential conditioning treatment, and after the expiration of the 25 sec. period.

Discussion

The results of this experiment indicate that the degree to which a CS allows S to predict US occurrences is an important variable in Pavlovian fear conditioning. Stimuli which signalled increased probability of the US became elicitors of fear, resulting in an increased jumping rate, and stimuli which signalled decreased probability of the US became inhibitors of fear, resulting in a decreased jumping rate. The results, therefore, substantiate the findings of Rescorla & LoLordo (1965), that active inhibition and excitation of fear can be induced by Pavlovian methods. However, these effects seem to be independent of the more traditionally emphasized effects of number of CS-US pairings. Despite the fact that Ss in Group R received at least as many pairings of the CS and US as Ss in Group P, only the Ss in Group P showed evidence of Pavlovian fear conditioning.

The temporal location of the effect produced by the CS is also of interest. The differential effects of the CS for the three groups were primarily confined to the periods immediately following CS onset. Perhaps this happened because shocks were uniformly distributed, and for Group P the probability of a US in the next 30 sec. was maximal just after CS onset and declined as time since the CS increased; but for Group N, the probability of a shock was minimal immediately after CS onset. Another possibility is that the period immediately after CS onset is simply more discriminable from the baseline conditions than are subsequent periods.

These results suggest that we consider as a basic dimension of Pavlovian conditioning the degree to which the US is contingent upon prior CSs. From this point of view, the appropriate control procedure for non-associative effects of Pavlovian conditioning, such as sensitization or pseudoconditioning, is one in which there is no contingency between CS and US. The two extremes in which CS predicts either the increased or the decreased probability of a US are seen in the present experiment to produce, respectively, excitation and inhibition. A procedure such as that of Group R in which there is no contingency between CS and US provides an appropriate control procedure against which to evaluate both of these effects.

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Notes

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Punishment of instinctive behavior: Suppression of mouse-killing by rats¹

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Rats that consistently killed mice stopped killing when attacks were punished by electric shock. Punishment suppressed rather than eliminated the behavior, for the rats eventually resumed killing after the termination of punishment. The suppressive effects of punishment on killing were quite enduring, however, for suppression was exhibited as long as 60 days after punishment.

In contrast with the extensive literature on the punishment of instrumental responses, little is known of the effects of punishment on "instinctive" or "consummatory" behaviors (Church, 1964; Solomon, 1963). The few available reports suggest that instinctive behaviors are suppressed when punished by the application of a painful stimulus contingent upon their occurrence (Beach et al, 1956; Adler & Hogan, 1963), although the facilitation of instinctive behaviors by punishment has also been described (Moltz et al, 1956; Ulrich et al, 1964). The study reported here was conducted to explore the effects of punishment on mouse-killing by rats. Some rats kill mice "spontaneously" and consistently, whereas other rats of similar genetic and environmental background never kill mice. The factors responsible for the development of this "spontaneous" killing have not been identified, but it is known that the killing response, once established, is highly stereotyped and stable (Karli, 1956; Myer, 1964), and that the opportunity to kill can serve as a "reinforcement" for the learning and maintenance of instrumental behavior (Myer & White, 1965). In the present study rats that consistently killed mice were punished for attacking mice until they stopped killing, after which punishment was discontinued and recovery tests were administered.

Method

To select Ss, 33 adult male hooded rats were placed in individual cages and, after a three-day adaptation period, an adult mouse was placed with each rat. The bodies of mice that were killed were removed 15-45 sec. later, to prevent feeding on them by the rats, and mice that were not killed were removed after 5 min. One such pretest was conducted each day for 10 consecutive days. Twelve rats that killed mice on all 10 pretests served as Ss in the remainder of the study. One hour after the tenth pretest the Ss were moved to grill boxes in the experimental room, where they were maintained throughout the study. The grill boxes were 9 x 8 x 8 in. high, with a grid floor composed of 16 stainless steel bars, aluminum end walls, transparent plastic side walls, and a hinged Masonite top.

Each box was continuously illuminated from behind one transparent wall by a 7.5 watt light bulb, and the other transparent wall was covered by a one-way mirror, through which the interior of the box could be viewed. Mice were introduced and removed through a small "trap-door" in the lid of each box. Food and water were always available to the rats, and white masking noise was continuously present in the experimental room. Scrambled electric shock was delivered to each grill box by a Grason-Stadler E1064GS shock generator. Average current was 1.5 ma, measured through a 100,000 ohm resistor at the grid.

Each rat was presented one mouse each day for five days following removal to the grill boxes. Beginning the next day mouse presentations continued daily, but a single 3-sec. duration shock was administered when the rat seized a mouse. Only one shock was given on each daily trial, regardless of the rat's behavior during and after the shock. If no attack occurred during the 5-min. period, no shock was administered and the mouse was removed. This procedure continued until the rat reached the suppression criterion of failure to attack on three successive daily trials, after which daily testing with mice continued but no further shocks were administered. Tests were continued until a recovery criterion of kills on ten successive days was attained.

Results

Punishment contingent upon attack effectively suppressed killing by all 12 rats. When shocked for attacking, the rats usually continued biting the mice, but occasionally a rat withdrew from the mouse during shock and did not return and kill it during the 5-min. test period. Thus, somewhat fewer attacks than kills occurred during the punishment phase of the experiment. Table 1 shows the mean, median, and range of trials, attacks, and kills which occurred during the punishment phase of the experiment. Eleven of the 12 rats reached the suppression criterion after one to three punished attacks and within five days of the institution of punishment, and the twelfth rat reached the suppression criterion after six punished attacks in nine days.

Table 1. Mean, Median and Range of Trials, Attacks and Kills Required to Suppress Killing

	Mean	Median	Range
Trials	3.25	2.5	1-9
Attacks (Shocks)	2.58	2.0	1-6
Kills	2.25	2.0	0-6

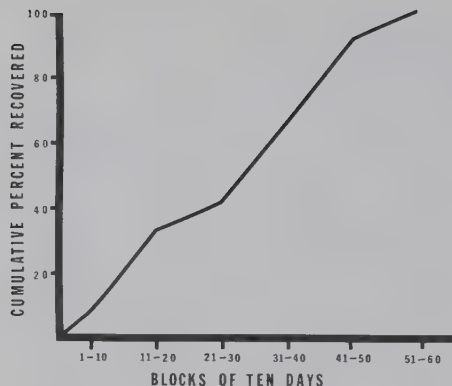


Fig. 1. Cumulative percentage of rats which reached the recovery criterion of kills on 10 successive daily trials on successive blocks of 10 days after the termination of punishment.

The recovery tests showed that the effect of punishment was to suppress, rather than eliminate, the killing response. The suppressive effect of punishment was, however, quite enduring. The course of recovery of killing is presented in Fig. 1, which shows the cumulative per cent of rats which attained the recovery criterion. One rat resumed killing on the day after reaching the suppression criterion, and killed consistently thereafter. The remaining 11 rats all displayed frequent reversals of reaction to the mice before killing again stabilized.

Discussion

The present investigation showed that punishment has a marked suppressive effect on mouse-killing by rats. Observation of the reaction of the rats on the punishment trials and the recovery tests suggested that the suppression was a result of conditioning of fear of the mice, and that the resumption of killing was due primarily to the extinction of fear as a result of repeated presentation of mice without association with shock. On early recovery tests the rats "froze" when presented

mice, and remained unmoving throughout the 5-min. test periods. As testing progressed, the rats displayed more activity when presented mice, and made tentative attacks which became more vigorous if the mouse fled, but were terminated if the mouse remained motionless or resisted the attack. Even after the rats had resumed killing consistently, they frequently displayed unusually long attack latencies, suggesting that the mice continued to arouse fear even after killing had recovered.

The remarkable persistence of the suppressive effects of punishment after shock was discontinued seems to confirm Solomon's (1964) observation that punishment exercises pronounced suppressive effects on consummatory, as contrasted with instrumental, behavior. Whether this apparent sensitivity to punishment is a general characteristic of "instinctive" or "consummatory" behaviors as a class or is a result of the use of particularly effective punishment techniques in the few studies of this problem can be determined only by further experimental analysis of the relevant parameters.

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Notes

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The Kamin effect in fish¹

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The effect of intersession interval on the relearning of an incompletely learned shuttlebox avoidance response in fish was investigated. The results revealed a U-shaped function, with the poorest performance occurring 24 hr. after original learning.

Studies of the relearning of an avoidance response in the shuttlebox have been carried out by a number of investigators (Kamin, 1957; Denny, 1958; Segal & Brush, 1959; Denny & Ditchman, 1962; Brush, Meyer, & Palmer, 1963; Brush, 1964). In each case, the results have indicated the presence of what is commonly referred to as the "Kamin Effect." This phenomenon manifests itself in the form of a decrement in performance at rather specific time intervals during the relearning phase of the experiments. The present study was designed to investigate the possibility of the existence of the Kamin effect at a different phyletic level, since all previous work had been done with the white rat as S.

Method

The Ss for this experiment were 63 experimentally naive goldfish, 2 in. to 3-1/2 in. in length. They were obtained locally and housed for several weeks in 20 gallon community tanks. Two days before training began, they were placed in individual tanks which were heated and continuously aerated. The apparatus was an aquatic shuttlebox built from an 18 in. Betta splendens display tank. The tank was divided into two compartments of equal size by a gray Plexiglas doorway, and was enclosed in a plywood shell which contained two 25 watt bulbs, one at each end of the shuttlebox. The CS was the onset of the light at the end of the compartment occupied by S, and the US was an electric shock delivered through a pair of electrodes set in the ends of the tank. The shock was developed from a 110 volt source passed through a variable resistor and pulsed by a shock interrupter. The shock level used was the lowest voltage required to bring about consistent escape responses on the part of pilot Ss. A pair of Hunter interval timers controlled the onset and duration of the CS and US, and a Standard electric timer recorded latencies to the nearest .01 sec. Six identical shuttleboxes were used.

Each S was given a 30 min. adaptation period in the shuttlebox on the day preceding the beginning of training. Twenty-four hr. later, each S was given 10 pretraining trials during which only the CS was presented. The light followed the fish from compartment to compartment for a period of 20 sec. per trial. Ss were dropped from the study if they avoided the CS on more than 5 of the 10 pretraining trials, or on more than 2 of the last 5 trials.

Three Ss were eliminated for this reason. Three min. after the 10th pretraining trial, original learning trials began and continued until three avoidances had occurred. A delayed conditioning procedure was used, with a 10 sec. CS-US interval, and a 5 sec. shock. A 3 min. intertrial interval was used throughout the study. A response to the CS alone terminated the CS and allowed S to avoid the shock completely. A response during the 5 sec. shock period terminated the light and the shock. The CS and the US were terminated automatically at the end of 15 sec. on those trials where S failed to make a response. Three min. after making the third avoidance, S was removed from the shuttlebox and placed in his home tank for the appropriate intersession interval.

Twelve Ss were assigned to each of five intersession intervals; .08 hr. (5 min.), 1 hr., 4 hr., 24 hr., and 168 hr. (1 week). At the end of their respective intersession intervals, Ss were returned to the shuttleboxes for the relearning phase of the experiment. Relearning for all groups consisted of 40 trials of avoidance training which were the same as those in original learning.

Results

The five intersession interval groups were matched on the basis of the number of trials required to make the third avoidance during original learning. Means for the individual groups of Ss were 11.25, 11.08, 11.00, 11.67, and 11.00 for the .08, 1, 4, 24, and 168 hr. groups respectively, with the grand mean for all five groups being 11.25.

The effect of intersession interval on the number of trials required to relearn to the original criterion of three avoidances can be seen in Fig. 1. This figure shows clearly that rate of relearning was a decreasing function of intersession interval up to 24 hr., but that it was an increasing function beyond that point. Analysis of variance indicated that this effect was significant beyond the .05 level of confidence ($F=2.67$, $df=4/55$). The effect of intersession interval on relearning was further observed by plotting the number of avoidances made in successive blocks of 10 trials. No change in the function from that shown in Fig. 1 was observed.

Discussion

The results of this study indicate that rate of relearning in fish is a function of intersession interval. This has previously been demonstrated with rats as Ss by Kamin (1957) and Brush, Meyer, & Palmer (1963). The basic difference between the results of the work with rats and the present study centers around interval time. In the present study, intersession interval seems to have little effect until after the 4 hr. period. The number of trials required to relearn to the criterion

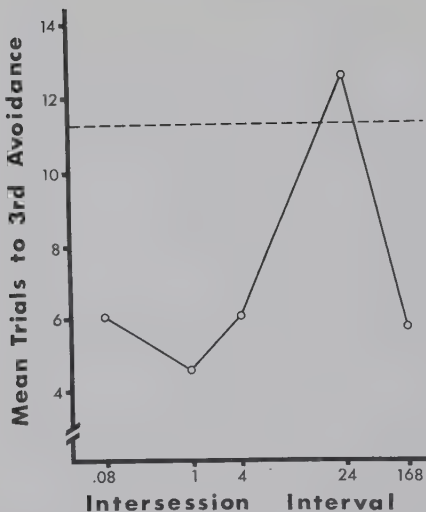


Fig. 1. Mean number of trials required to relearn to the original criterion of three avoidances. The dashed horizontal line at the 11.25 point indicates the grand mean number of trials required to reach the criterion of three avoidances during original learning. Intersession intervals are plotted on a logarithmic scale.

avoidance for the .08 hr., 1 hr., 4 hr., and 168 hr. groups differs very little, but the 24 hr. group required more trials to relearn than it did during original learning. Mean trials to criterion during original learning for the 24 hr. group was 11.67, while they required 12.33 trials to relearn to the same criterion. Other research now in progress bears out this relationship.

The 24 hr. decrement is surprising, since previous work indicated that the greatest interference was at the 1 hr. to 4 hr. intervals. A phyletic difference was expected, but not one of this magnitude. It may be that the time periods chosen for this study were not fine enough to locate the true interval of greatest interference. Further research with fish needs to be done with intersession intervals closer to the 24 hr. period

than the 4 hr. and 168 hr. intervals used in the present experiment. The phylogenetic difference revealed by this study also suggests that a worthwhile line of research would be one comparing the Kamin effect across a wide range of species.

These data would seem to support the "parasympathetic over-reaction" explanation of the Kamin effect suggested by Brush, Meyer, & Palmer (1963). They suggest that this reaction follows original fear conditioning, and that Ss are ill-equipped to deal with the stress of relearning if the relearning trials are initiated at or near the peak of the over-reaction. Figure 1 indicates that the decrement begins sometime between 4 hr. and 24 hr., reaches its peak around 24 hr. after original conditioning, and returns to its preconditioning level by 168 hr. As stated above, a closer look at time intervals between 4 hr. and 168 hr., with attention focused around the 24 hr. point, needs to be taken.

The results would further suggest that a close look be taken at the common experimental procedure of avoidance conditioning of fish which calls for blocks of 10 or 20 trials separated by 24 hr. periods. The results of such studies must certainly be contaminated by the Kamin effect.

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Note

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Social interaction between rats on different schedules of reinforcement¹

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Twelve Long-Evans rats were individually trained on different schedules of reinforcement and then run in pairs in a two-lever cage. Results indicated that various classes of social behavior could be experimentally produced and studied in the same manner as individual behavior by manipulating schedules of reinforcement

Although operant methods have enjoyed widespread application in recent years, they have not significantly penetrated the field of social behavior among animals. Animal social behavior has remained largely in the domain of the ethologists—with emphasis on natural observations rather than on manipulation.

The following experiment was designed to investigate social interaction among rats as a function of individual schedules of reinforcement. Specifically, in exploring various combinations of schedules, we were looking for the emergence of any of the categories of social behavior (such as *dominance* or *cooperation*) as defined analytically by Keller & Schoenfeld (1950).

Method

Rats were trained in a two-lever Skinner box with a removable Plexiglas divider separating the two levers. During training the rat was confined to one side of the box; the rats were trained to stable performance.

Individual schedules of the six pairs were as follows:²

	Left lever (A)	Right lever (B)
Pair 1	DRL 10	FR 10
Pair 2	DRL 10	FR 20
Pair 3	DRL 10	FR 4
Pair 4	DRL 10	FR 10
Pair 5	FR 3	FR 30
Pair 6	FR 3	FR 30

Each experimental session consisted of running an A rat and a B rat together with the Plexiglas divider removed and the levers programmed to the respective pretrained schedules. During each session the data consisted of cumulative response curves and number of responses emitted on the untrained lever. Photographic records were obtained during a portion of the sessions.

Results

Figure 2 indicates that in pairs 1 through 4, B responded more on A's lever during the first half of the session than during the second half. This fact cannot be readily explained in terms of extinction because DRL lever reinforcement was available to B with an equal probability throughout the session. It should also be

noted that although this decreasing trend was evident in all four pairs of animals, the actual number of B's responses on the A lever was smallest for pair 3, the pair whose B animal had the greatest probability of reinforcement on his own (FR 4 lever).

In all four pairs, A aggressed against B early in the session when B entered A's side of the cage. As the session progressed, A ceased attacking B and merely drove B away with postural responses. At no time did A attempt to respond on B's lever. B ate the pellets he worked for but rarely was allowed to eat those for which A had worked.

In pair 5, after less than 2 min. of responding on his own (FR 30 lever), B began responding on A's (FR 3) lever and also eating pellets which A had worked for. Throughout the remainder of the session both animals remained at the A lever and alternated lever pressing and eating. In pair 6, although B did obtain a total of 12 reinforcements at his own (FR 30) lever, both animals exhibited the same behavior pattern as pair 5; that is, cohabiting A's side of the cage, and alternating lever pressing plus eating from A's food tray. In neither pair 5 or 6 were there signs of aggression nor did A respond on B's lever.

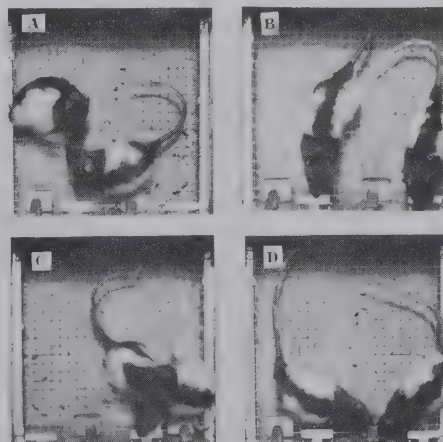


Fig. 1. (A) Initial exploratory behavior typical of all six pairs of subjects in two-lever situation. (B) Brief period of "individual" behavior prior to social interaction. The length of this period appeared to be a function of the schedule on which B was trained. (C) Typical interaction of A and B rats (pairs 1-4) following B's entrance to DRL side of cage. (D) "Compatibility" typical of Fixed Ratio animals of pairs 5 and 6 on A's side of cage.

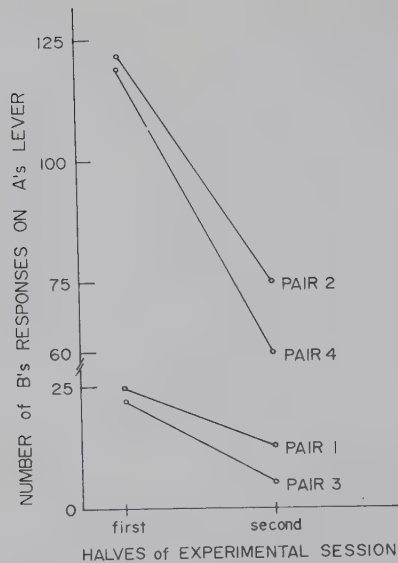


Fig. 2. Number of responses emitted by B animal (FR trained) on A lever (programmed on DRL 10) during first and second halves of each experimental session. Each half was defined by the delivery of 25 DRL reinforcements.

Discussion

This experiment has attempted to demonstrate that with same-sex animals of equal food deprivation, age and weight, social interaction can be manipulated by individual schedules of reinforcement.

The individual and social behavior observed is consistent with characteristic schedule performance. For example, DRL animals are known to establish complex "time consuming" behavioral chains (Hodos, Ross, & Brady, 1962; Davis & Wheeler, 1966). Such animals generally remain "chain-bound" and emit no new responses unless directly interrupted. Consistent with this is the fact that the DRL animals in the current experiment remained working at their own levers and did not sample the other available lever.

The behavior of the fixed ratio rats on the DRL lever was also characteristic in that all such responses on the opposite lever occurred during the pause times immediately following reinforcements. Thus, while the DRL animals could be expected to remain "chain-bound" until directly disrupted, the fixed ratio animals could be expected to sample or initiate other behaviors during

pause time. The previously described decrease in aggression and increase in threatening postural responses by A is typical of the dominance pattern described by Keller & Schoenfeld (1950). In their terms, A has "...become a strong secondary negative reinforcer and discriminative stimulus (S^D) to the extent that a mere gesture will lead the submissive animal to beat a hasty retreat" (p. 356).

The case of pairs 5 and 6 is of special interest in that A (FR 3) allowed B (FR 30) to work with him at the "hotter" lever. It is suggested that A did not drive B away because (1) there was no disruption of a complex ongoing chain as there had been with the DRL animals, and (2) there were pellets enough for every rat on the FR 3 schedule. Thus, in contrast to pairs 1 through 4, the experimental situation of pairs 5 and 6 was structured to allow both animals compatible existence within A's territory.

Conclusions

Beyond the realm of elicited or hormonally-controlled responses, behavior in the multi-organism situation may be under the control of a variety of social and non-social stimuli. Although only a few of a sizable number of possible schedule pairings have been presented in this exploratory study, we are led to believe that if potential eliciting factors (sex, weight, etc.) are held constant, traditional categories of social behavior may be brought under the same degree of experimental control that has been exercised over individual behavior by schedules of reinforcement.

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Notes

- From Bureau of Medicine and Surgery, Navy Department, Research Task MF022.01.03-1002. The opinions and statements contained herein are the private ones of the writers and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.
- On the FR (Fixed Ratio) schedule, reinforcement is contingent upon every n^{th} response. Thus, on an FR 10, each tenth response is reinforced. On the DRL (Differential Reinforcement of Low Rates of Response) schedule, reinforcement is contingent upon the passage of a specified minimum inter-response time. On the DRL 10 sec., for example, only a response which follows the previous response by at least 10 sec. is reinforced. Responses occurring sooner than the completion of the specified 10-sec. interval automatically recycle the timing mechanism and are not reinforced.

Differential conditioning and subsequent choice: Partial vs. continuous reward¹

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Three groups of rats received 0, 48, or 138 differential conditioning trials in which 50% of the responses to one cue were rewarded and 100% of the responses to the other cue were rewarded. With extensive training speeds to the 50% cue exceeded those to the 100% cue in starting and running segments of the alley, while the reverse relationship obtained in the goal-entry speeds. Subsequent choice of cues was little affected by the differential conditioning.

Amsel et al (1964) found that rats' asymptotic starting and running speeds eventually were faster when confronted with a discriminandum or cue associated with partial (50%) reward as compared with continuous (100%) reward. However, this effect, which duplicates within Ss a relation previously found to obtain between Ss (Goodrich, 1959), was not observed by Pavlik et al (1965). The present research sought to replicate these differential conditioning findings and determine what effect establishing such differential response strength has on behavior when S is subsequently permitted to choose the cue to which to respond.

Only the second of two studies is detailed below since the first failed to produce differential speeds to the two cues. A possible reason for this failure is discussed.
Method

The Ss were 48 female albino rats, 72 days old at the beginning of the study. The apparatus consisted of a sliding, grey startbox (SB) and four, juxtaposed, straight alleys, two painted flat white and two black. The SB could be situated such that S was confronted with one of two pairs of alleys, with either a white alley to his left and a black alley to his right or vice versa. The apparatus was 4 in. high covered with clear Plexiglas throughout. Alleys were 38.5-in. long and 3.5-in. wide except for the first 7 in., in which the outside walls of each pair of alleys narrowed toward the median until they were 2 in. apart where they met the SB. The first 7 in. of the median wall separating the two alleys of each pair was removed resulting in a triangular-shaped choice area. The 10.5-in. long SB was 3.5-in. wide at the rear door and 2 in. wide in the 8 in. nearest the alleys. Guillotine retract doors were located 8 in. and 26.5 in. from the SB. The latter defined the goal boxes and the former were used to force S's response to the alternative alley during differential conditioning. Photobeams located at 12 in. intervals down the alleys permitted, in conjunction with a microswitch on the SB door, three successive time measures as S traversed an alley. These measures were converted to ft./sec. and called start, run, and goal speed, respectively.

Three groups of 16 Ss, placed on a 24-hr. feeding cycle on Day 1 of the study, received different amounts of differential conditioning prior to the choice phase. Group 138 received 138 trials from Days 24-49 at the rate of six per day except for Day 24 on which it received one trial, Day 25 on which it received two, and Days 26-28 on which it received three. Group 48 received 48 trials from Days 41-49 also at the rate of six per day except for Days 41-42 on which it received three per day. Group 0 received no differential conditioning prior to the free choice phase, which lasted from Days 50-56, six trials per day for all groups.

The Ss were run in rotation in squads of eight from a single group. Four had 50% of their trials in a black alley rewarded and 100% of their trials in a white alley rewarded, while the other four Ss had the colors reversed. From Day 20 until the beginning of the choice phase all Ss received 24 97-mg Noyes food pellets per day either as reinforcement (six per trial) or incorporated into their daily ration. Similarly Ss not receiving training while others were being conditioned were handled daily to roughly equate this factor.

During differential conditioning number of rewards in the 50% and 100% alleys was equated within a block of six trials resulting in four trials to the 50 and two to the 100% cue. During the choice phase responses to the 100% cue continued to be rewarded as were about half of the responses to the 50% cue.²

Results and Discussion

Differential Conditioning Phase: Mean speeds of Group 138 to the 50% and 100% cues are shown in Fig. 1. Analyses of variance over Blocks 7-11 indicated that asymptotic speeds were faster to the 50% cue than to the 100% cue in starting and running speeds, $F=30.37$ and 40.81 , $df=1/14$, $p<.001$, respectively, but slower in goal speeds, $F=4.52$, $df=1/14$, $p<.05$. Speeds for Group 48 were similar to the first four blocks of Fig. 1 but they were not significantly different at Block 4.

These data replicate the findings of Amsel et al (1964). Since this second study and Amsel et al used fairly large rewards (six 97 mg and two 500 mg pellets), while the first study and Pavlik et al (1965) used smaller rewards (two and five 45 mg pellets) and failed to obtain differential speeds, the factor of reward magnitude may be critical.

As may be noted from Fig. 1, as well as the data of Group 48, speeds to the 50% cue were generally faster than speeds to the 100% cue rather early in training. This probably results from the procedure of equating rewards but not responses to the two cues, which, according to

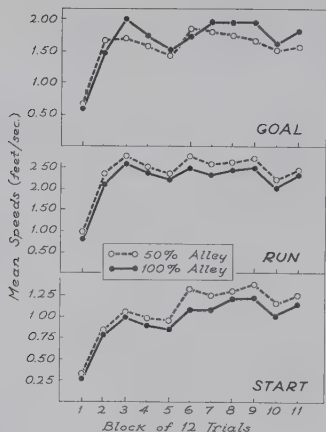


Fig. 1. Differential conditioning response speeds of Group 138 to the two cues in the three segments of the response chain. Speeds are averaged into blocks of 12 trials except for Block 11 in which there are 18 trials.

a contiguity theory, would result in the 50% cue developing habit strength at a faster rate than the 100% cue (Ramond, 1954).

Choice Phase. Within each block of six trials speed measures were calculated for Ss which made at least one response to each cue (start speeds are plotted in Fig. 2). Means for Ss over the first three and last four blocks were the units in separate analyses performed for early and late trials, with Groups, Reward schedule (100% vs. 50%) and Color of the cues as factors. These analyses generally supported the following statements: Group 0 displayed little apparent difference between speeds to the 50% and 100% cues in any measure, while, in contrast,

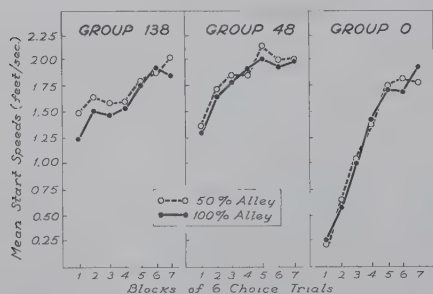


Fig. 2. Response speeds to the selected cue during the 42 choice trials.

Group 138 displayed the differences established during differential conditioning although these differences were small in the run speed measure and tended to attenuate in both the start and run measures. In the goal measure the speeds of Group 138 to the 100% cue remained substantially above those to the 50% cue throughout the 42 choice trials. Group 48 displayed speeds similar to Group 138 except that the initial superiority of the 50% cue in start speed was small.

Percentage choice of the 50% cue was determined for each day of the choice phase. None of the groups displayed any clear preference for either cue over the seven days. The percentages of trials on which the 50% alley was selected during the first three days were 46.2, 51.4, and 52.7 for Groups 0, 48, and 138, respectively. For the last four days the percentages were 42.2, 51.1, and 49.0. Although the differences are in the direction of increased selection of the 50% cue with prior differential conditioning, analyses over all days or only the first three days revealed no significant effect of Groups ($F_s < 1$). There was a strong preference for black regardless of reward probability ($p < .001$).

These results are consistent with the conclusion that the differential conditioning was irrelevant for subsequent cue preference. However, there was a suggestion that position preferences were strengthened by at least the intermediate amount of prior conditioning. According to several stringent criteria of consistency, a preference for an alley in a particular position with respect to the SB (to the left or right) was most prevalent in Group 48 and least in Group 0. Applying the criterion that 37 of the 42 choice trials must display the preference, there were 4, 13, and 6 Ss from Groups 0, 48, 138 meeting this definition, indicating that the occurrence of a rigid position preference was not independent of the groups factor, $\chi^2 = 11.19$; $df = 2$, $p < .01$.

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Notes

1. This investigation was supported in part by Public Health Service Research Grant MH 11029 from the National Institute of Mental Health.
2. Upon request further details are available in an expanded version of this paper.

Recovery from prolonged barbiturate sleep in the rat¹

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Prolonged sleep was produced by periodic injections of pentobarbital. This sleep consisted predominantly of slow waves and spindles. No paradoxical sleep waves were observable in the cortex during the drug treatment. Following discontinuation of the drug, the amount of slow wave sleep decreased and paradoxical sleep increased when compared to a control period, suggesting a partial satiation of slow wave sleep and deprivation of paradoxical sleep by the treatment.

This experiment is concerned with the need for sleep; in particular with the susceptibility of sleep to satiation, with special reference to the two phases of sleep. Two phases of sleep thought to be qualitatively different have been delineated both in the human (Dement, 1965) and the rat (Swisher, 1962). The two phases in the rat are slow wave sleep (SWS) consisting of 1-3 c/sec. activity with spindling, and paradoxical sleep (PS) consisting of 6-8 c/sec. activity (Swisher, 1962). The paradoxical phase is thought to be analogous to Rapid Eye Movement (REM, dream) sleep in humans (Dement & Kleitman, 1957).

The purpose of this experiment was to determine the effect of a 24 hr. period of pentobarbital induced sleep on subsequent sleep.

Method

Bipolar cortical electrodes (right frontal to occipital) were surgically implanted on the dura of four adult male Long-Evans rats. One week elapsed between surgery and beginning the experiment. EEG was recorded with a Grass III-D unit. The Ss were placed in individual cages in the experimental room 24 hr. prior to the beginning of recording; the first 6 hr. of EEG data were discarded as an additional adaptation period. The room was sound deadened, temperature was maintained at 67 to 69°F., and the lights were on 12 hr. and off 12 hr. each day.

Waking, SWS, and PS were scored according to the criteria described by Swisher (1962). The control sleep cycle was recorded by EEG for 24 hr. Following this control period, sleep satiation was attempted by producing a prolonged sleep period lasting 24 hr. Pentobarbital sodium (40 mg/kgm IP) was injected at the beginning of the drug period and then further injections were given whenever four consecutive waking minutes were present in the record. Injections were required approximately every 3-4 hr. The drugged period was followed by 24 hr. of post-drug recording.

Results

The EEG during the drug period (satiation period) consisted almost entirely of slow waves and spindles

similar to normal SWS in the rat, but with a higher frequency of spindles; no evidence of PS was present in the record. Small amounts of waking activity, amounting to less than 10 per cent of the total record were present.

Table 1 summarizes the data from this experiment. During the satiation period the amount of waking and PS is significantly less than pre-and post-treatment and the amount of SWS is greater ($p < .001$ for all 6 comparisons).

When the pre-treatment day is compared to the post-treatment day, the decrease in SWS is significant ($p < .05$), but the increases in amounts of waking and PS do not reach statistical significance. However, there was a significant increase in PS expressed as a percentage of total sleep during the post-treatment (recovery) period ($p < .01$).

Discussion

The suppression of PS during barbiturate induced sleep is in agreement with experiments using human Ss, which have found barbiturates to depress REM sleep (Oswald, Berger, Jaramillo, Keddle, Olley, & Plunkett, 1963). It is likely that the total depression found in this experiment in contrast to the limited depression in human Ss is due to the dosage differences (a sedative dose in the human vs. an anesthetic dose in the rat).

The finding of an increase in PS post-treatment is consistent with the suppression of this phase during the satiation period. This increase in PS following its deprivation has been found by other investigators (Dement, 1960; Siegel & Gordon, 1965). Since barbiturate sleep does not mimic normal sleep but actually results in the deprivation of PS, a question would seem to be raised about this means of provoking sedation.

The idea that sleep functions as a need is supported both by the rebound increase in PS following its deprivation and the decrease in SWS following satiation. The finding that barbiturate induced sleep consists of only one sleep phase and that SWS and PS respond

Table 1. A summary of the sleep cycle changes produced by pentobarbital - induced sleep.

	Pre-Treatment	Satiation-Period	Post-Treatment
Minutes			
Waking	790	135	838
PS	.81	0	106
SWS	569	1305	496
	1440	1440	1440
PS as a per cent of total sleep	12	0	18

Mean values for the four rats.

differentially to this treatment lends support to the suggestion that there are at least two kinds of sleep; qualitatively distinct and subserving different functions (Dement, 1965; Jouvet, 1960).

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Notes

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2. Now at the University of Pittsburgh.

The interaction between sensory and tonic factors in the perception of the vertical in pigeons:

II. A replication via an alternative procedure¹

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Ten pigeons were given VI training to peck a key illuminated by a white vertical line in an otherwise dark Skinner box. For 5 Ss the floor was tilted 24° to the left; for 5 Ss it was tilted 24° to the right. Generalization testing in extinction to other visual angles with the floor horizontal revealed a displacement of the mode of responding in the direction opposite that to which the floor was tilted in training. The results indicate that apparent vertical is displaced in the same direction and approximately to the same degree as the floor is tilted. They are thus in complete agreement with other studies in which Ss were trained with the floor flat and tested under various floor tilt conditions.

In a recent study, Thomas & Lyons (1966) reported evidence for an interaction between sensory and tonic factors in the perception of the visual vertical in pigeons. In two separate experiments, pigeons were trained to peck a key illuminated by a white vertical line in an otherwise dark experimental chamber with the floor in a flat (horizontal) position. After variable interval training, the pigeons were tested in extinction for generalization to other visual angles with the floor inclined 24° to the left or to the right. The birds showed enhanced responding to angles inclined toward the side to which the floor was tilted. The mode of the generalization gradient (and thus presumably the apparent vertical) was displaced to an angle inclined 30° from true vertical, and since the floor was inclined 24° in the same direction, the authors concluded that quite probably no compensation for floor tilt had taken place.

The present study provides an extension of the Thomas & Lyons (1966) findings. It involves training the Ss to respond to a true vertical S^D with the floor tilted 24° and then testing for generalization with the floor flat. If the apparent value of the training stimulus is indeed displaced approximately 24° from true vertical in the direction of the floor inclination, this distortion should be reflected in a displacement of the peak (mode) of the gradient obtained (with the floor flat) in a direction opposite that to which the floor was tilted in training.

Method

Subjects. The Ss were 10 experimentally naive adult homing pigeons maintained by restricted feeding at approximately 75% of their ad libitum weight.

Apparatus. The apparatus consisted of two Grason-Stadler pigeon chambers with associated automatic programming and recording equipment. Industrial Electronics Engineers In-line display cells provided the stimuli.

Procedure. Following magazine and key peck training the Ss were given two days of 50 continuous reinforcements each and then 10 daily 1/2-hr. sessions of 1-min. variable interval training. A white vertical line 7/8 in. high by 1/8 in. wide illuminated the key throughout training; the chamber was otherwise dark. Throughout training, for Ss No. 1-5 the floor was inclined 24° to the right; for Ss No. 6-10 the floor was inclined 24° to the left.

Immediately following the 10th VI training session, the birds were removed from the experimental chambers, the floors were adjusted to a horizontal position, and the birds were returned for generalization testing in extinction. The five test stimuli (30° , 60° , 90° (S^D), 120° , and 150°) were randomized within a series and six different random series were presented to each S. Stimulus presentations were for 60 sec. with no intervening blackouts.

Following this test, all Ss were retrained under the original floor tilt condition for five more days. After the fifth of these, they were given a second generalization test similar to the first.

In order to give each generalization test equal weight, each S's gradient on each test was converted into per cent of total responses to each of the five test stimuli. These per cent scores were then averaged over the two tests and the mean of the average gradients for each

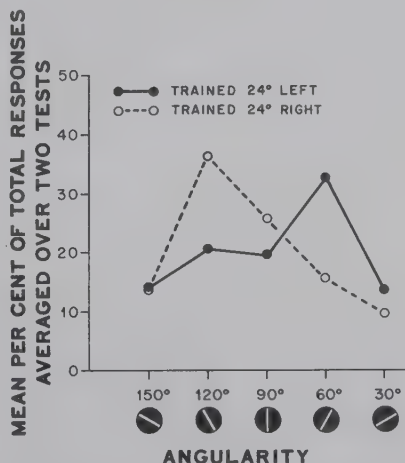


Fig. 1. Mean relative generalization gradients (pooled over two tests) for Ss trained under two different floor tilt conditions.

group of five Ss is presented in Fig. 1. As predicted, the modes of the obtained generalization gradients are displaced 30° opposite the direction of the floor tilt employed during training.

For purposes of statistical treatment, again the data were pooled for the two tests. This time the measure employed on each test was the per cent of total generalized responses (i.e., values to stimuli other than 90°) to stimulus values less than or greater than 90°. These scores were averaged for the two generalization tests, and then a t test was performed comparing for all 10 Ss the mean per cent of generalized responses to stimuli inclined toward the side to which the floor was also tilted during training vs. the corresponding mean per cent to the opposite side. The value for the opposite side was significantly higher ($t=3.12$, $df=9$, $p<.02$) and 9 of the 10 Ss showed data in agreement with the group trend.

In another study recently performed by Lyons & Thomas (1966), the original finding by Thomas & Lyons (1966) was further extended. Four different groups were trained with the floor flat and tested with the floor inclined 0°, 12°, 24°, and 36° to the left. A fifth group was tested with the floor inclined 24° but with the chamber illuminated; this "lights on" group and the 0° group yielded symmetrical gradients peaking at the 90° training value; all other groups showed the predicted asymmetry, which was greatest under the 24° condition.

In combination with the present experiment, the studies by Thomas & Lyons (1966) and Lyons & Thomas (1966) demonstrate beyond doubt that, in the absence of veridical visual cues, postural feedback from floor inclination produces a systematic distortion in the perception of visual vertical.

There is no evidence in any of these studies to suggest that an adaptation to the floor tilt occurs such that apparent vertical more closely approaches true vertical with time. Where testing was done under the floor tilt condition there was no evidence for decreasing asymmetry as generalization testing progressed. In the present experiment if adaptation had occurred in the 1/2-hr. training session preceding each test (or cumulated over training sessions) the training stimulus

would have effectively been a succession of angles of increasing proximity to 90°. Following such training a relatively flat generalization gradient with much higher response strength at 90° than that actually obtained would have been expected. Certainly the possibility cannot be precluded that a degree of adaptation occurred which was beyond the measurement sensitivity of these experimental procedures, or that more prolonged exposure to the floor tilt condition might have revealed a measurable adaptation effect. There is, however, no evidence to support such a contention.

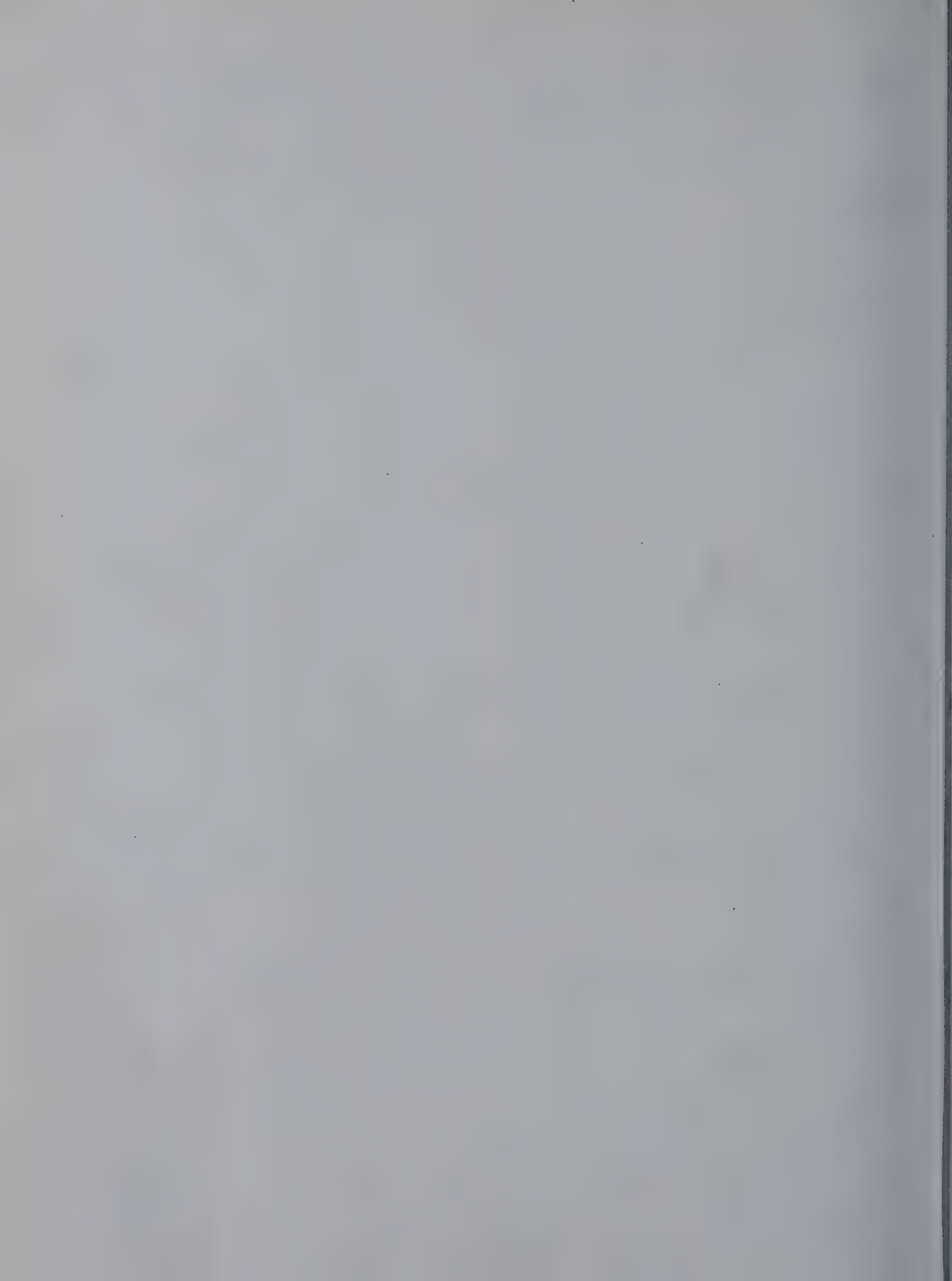
The displacement of apparent vertical in the same direction as the floor is inclined has also been demonstrated in humans by La Monica & Thomas (1966). In the more typical studies in which the human was passively tilted to the side (e.g. Werner, Wapner, & Chandler, 1951), the distortion tended to be an over-compensation rather than an under-compensation. This difference in procedure and results emphasizes the role of muscular involvement in influencing visual perception and may be interpreted within the framework of Werner & Wapner's "sensory-tonic field theory of perception" (1952).

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Note

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The sequential judgment of proportion^{1, 2}

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Ss gave percentage estimates of proportion, which were revised after each event during the presentation of a sequence of binary events. Responses exhibited constant errors of overestimation of proportions greater than .5 and underestimation of proportions less than .5. Both verbal and nonverbal responses were used, the constant error being somewhat greater for nonverbal responses. There was a tendency for the constant error to decrease as the number of events between revisions was increased.

In a sequential decision making task, a S must make a continuous re-evaluation of perceived events as they occur. One way of assessing the accuracy of this re-evaluation process is to have Ss make estimates of the proportion of times that some event has occurred. Constant errors in the percentage estimation of proportion have been reported by Shuford (1961), Erlick (1964), and Pitz (1965b), among others. The form of the constant error, however, has varied from one study to another. Both Erlick and Pitz used as stimuli sequences of binary events, with a single percentage estimate being given at the end of each sequence. The present study used similar sequences, but Ss were asked to make a revised percentage judgment after each event within the sequence. Sequential judgments were compared with estimates given only at the end of each sequence, and with judgments revised after differing numbers of events.

Method

The stimuli consisted of sequences of letters, 'B' or 'C', presented with a stimulus duration of 0.5 sec., and an interstimulus interval of 0.2 sec. The letters

were presented on an Industrial Electronics series 10,000 digital readout. All Ss were asked to estimate the percentage of 'B's during a sequence. Six different sequences of 30 letters were selected; the selection was not random, but rather was designed to provide three sequences of roughly constant proportions, and three of markedly changing proportions. Figure 1 shows one of the former sequences, and Fig. 2 one of the latter.

The study was run in two stages. In stage 1, verbal percentage estimates were compared with nonverbal, scale-and-pointer responses. Three groups of 10 Ss were used: Group 1a made judgments by means of verbal percentage estimates; Group 1b used a scale, marked at the zero, 50 and 100 per cent points only, with a pointer which was left where set between responses; Group 1c used the same scale, but returned the pointer to the 50 per cent point between responses. A control group, 1d, of 10 Ss, was run to determine to what extent there were constant errors in the perception of percentage distances along the scale. This group was given values of percentages, and was asked to set the pointer to indicate these percentages on the scale. In stage 2, all Ss used the same scale and pointer device as used by Group 1b. Five groups of 10 Ss were used, Groups 2a through 2e. The five groups were shown differing numbers of events between judgments: 1, 2, 5, 10, and 30 respectively, for sequences of 30 events.

Results

A convenient means of summarizing the results is to fit to the data from each S a linear function relating the logistic transformation of the stimulus and estimated percentages, i.e.:

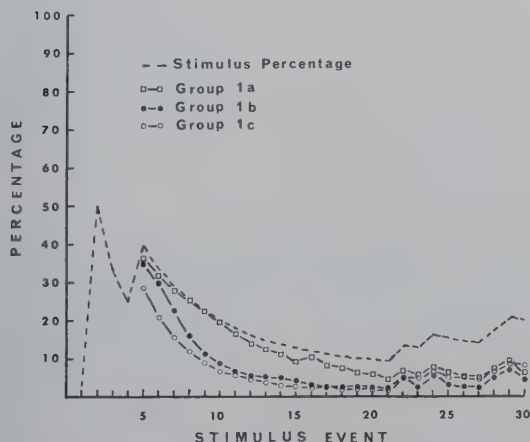


Fig. 1. Mean judgments by Groups 1a, 1b, and 1c to sequence 1.

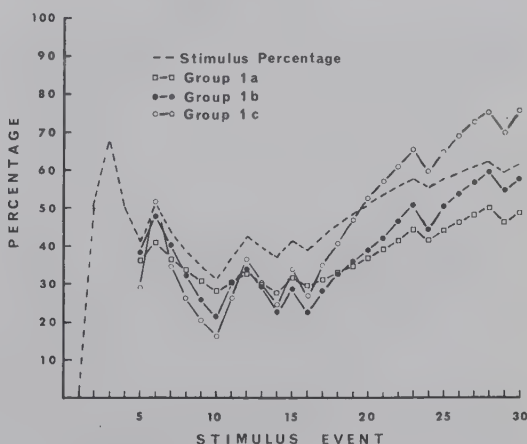


Fig. 2. Mean judgments by Groups 1a, 1b, and 1c to sequence 2.

$$\log [\hat{P}/(100-\hat{P})] = a \log [P/(100-P)] + b,$$

where P is the stimulus percentage, and $\hat{P}$ is the estimated percentage. This function is equivalent to an assumption that a power function, with exponent a , will describe the perception of ratios (see Pitz, 1965b). As an indication of the goodness of fit of this function, the average value of r^2 for individual Ss in this study was .85. The value of a gives an indication of the degree of constant error; if a is greater than 1, percentages greater than 50% are overestimated, and percentages less than 50% are underestimated. The mean value of a for Group 1a was 1.33, for Group 1b was 1.71, and for Group 1c was 1.72. All these means were significantly ($p = .01$) greater than 1. The degree of constant error was significantly larger for the two nonverbal groups than it was for the verbal group. Examination of mean responses by the control group, 1d, indicated no consistent or significant constant errors in placing the pointer to indicate specified percentages.

Figure 1 shows the average responses by Groups 1a, 1b, and 1c to one of the sequences of fairly constant stimulus percentage. Judgments for the first four events are not shown; they were almost invariably accurate. The form and magnitude of the constant error after event 4 is quite apparent. Figure 2 shows responses to one of the sequences of changing proportion. It is clear from this figure that there were sequential effects to be found, as well as the overall constant error. Judgments exhibited a lag in change as the stimulus percentage changed towards 50 per cent. The lag was greatest for Group 1a, and was very slight for Group 1c. These differences between groups were consistent over the three sequences of changing proportion, and showed up as significant Group by Event-Number interaction effects in analyses of variance for these sequences. This same lag in judgments can be seen to some extent in responses to the last 10 events of the sequence in Fig. 1.

Mean values of a for Groups 2a through 2e were 1.51, 1.60, 1.17, 1.29, and 1.40 respectively. Analysis of variance indicated a significant Groups effect ($p = .01$), but no pairwise comparison, using a Tukey (α) test (Winer, 1962) was significant at that level. All exponents except that for Group 2c were significantly greater than 1.

Discussion

Although Erlick (1964) found that in the percentage estimation of proportion, judgments tended to be too close to 50 per cent, Pitz (1965b) found a slight tendency towards the opposite kind of error, associated

with exponents a of greater than 1. Both of these studies used non-sequential judgments; in the present study, sequential judgments exhibited a pronounced tendency to be too extreme. Furthermore, with the use of non-verbal responses, the amount of error was even greater. Pitz (1965b) suggested that such a constant error may indicate a contrast effect occurring when a S is able easily to discriminate the two events occurring in a binary sequence. It is reasonable to assume that in giving his judgments sequentially, a S finds it easier to perceive the occurrence of 'B's separately from the occurrence of 'C's. Some support for this argument is to be found in the general tendency for constant errors, and possible contrast effects, to decrease as the number of events between judgments increased.

The reason for the discrepancy between verbal and nonverbal responses is not clear. However, Pitz (1965a) showed that the use of verbal-numerical responses in a magnitude estimation task induced irregularities in the resultant psychophysical scale, which appeared to be due to the existence of biases in the use of numbers. These irregularities did not appear when a nonverbal, magnitude production method was used. It is entirely possible, of course, that nonverbal response devices produce artifacts of their own, which affected responses in the present study.

The lag in judgments which is illustrated in Fig. 2 was apparently a function of a S's recall of his previous response. Group 1b left the pointer where it had been set between responses, and hence could see their previous response, while Group 1a could presumably recall their previous verbal response. These two groups exhibited the lag far more than did Group 1c, who returned the pointer to the 50 per cent position between responses.

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Notes

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2. Considerable assistance in the running of this experiment was supplied by Darrell Willis, to whom the author is very grateful.

A comparison of the English and metric system in a length estimation task¹

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Size estimates by English and metric system users were compared on a length estimation task. The results indicated that some differences exist between estimates of the two measurement system users but not in a systematic direction. A discussion was made that the unit of measure that one memorially constructs to estimate length may be greater than the basic unit.

The system of measurement used by natives of English speaking countries differs from the metric system in terms of the definition of the standard unit. A problem of interest to the behavioral scientist is whether differences in the units may be reflected in different estimations being made of the same physical quantity as a function of the measuring unit used. For example, estimation using the centimeter (cm) as the standard rather than the inch, results in estimates in terms of a smaller unit of measure. The magnitude of the standard (as well as the magnitude of the dimension estimated) may be an influential variable of the magnitude of the estimate. A second related variable is the effect of a history of commerce with a particular unit of measure. For a given system of measurement, using the familiar unit of measure for estimation of a physical quantity should result in more accurate or less variable estimates than using an unfamiliar unit of measure. An attempt was made to put this argument to test in the present study; however, for the most part this study was exploratory. The general question asked was whether any differences exist in estimates of the same physical stimulus by users of different measuring systems.

Subjects and Apparatus

Seventeen college-age males from an American university and 17 Danish citizens ranging in age from

18 to 32 years were used to estimate the length of three stimuli in terms of four physical and one verbal unit of measure. The stimuli were straight line drawings 8.73, 24.61, and 49.88 cm, painted on different-size cards of poster board. The lines extended diagonally across the cards. The units of measure used were line drawings painted on cards 216 by 279 mm. The four physical units were segments of 1 cm, 2.54 cm (1 in.), 4 cm, and 7 cm.

Procedure

A fifth response condition was used in which each S was asked to estimate and verbally report the length of the three stimuli using the unit of measure familiar to him. For the English system users (EU), estimates were given in inches, for the metric system users (MU), estimates were given in centimeters. No information was given about the length of the physical units of measure.

All Ss were individually tested. They were instructed to estimate the length of the stimuli in terms of the line segments which were presented for each stimulus, i.e., "Estimate how many of the line segments are contained in the line." The Ss were told to use fractions of a line segment if they wished. The presentation of the stimuli and the four units of measure were randomized for each S. Presentation of the verbally requested familiar unit was always last. In all, each S made 15 estimations.

Results

Table 1 presents a summary of the pertinent data characteristics. It was not possible to examine the effect of single and joint variation of the independent variables on size estimates by the analysis of variance because of the considerable differences in the variances of the subgroups. However, some qualitative differences

Table 1. Means, Standard Deviations, and Per cent Error for All Stimuli by All Units of Measure for English (EU) and Metric System Users (MU)

	Units of Measure									
	1 cm		2.54 cm		4 cm		7 cm		Familiar Unit	
	EU	MU	EU	MU	EU	MU	EU	MU	EU (in.)	MU (cm)
8.73 cm Stimulus Means	8.27	8.27	9.22	9.30	8.15	8.61	9.18	9.45	9.49	9.12
Standard Deviations	1.93	1.72	1.34	1.36	1.08	1.63	0.78	1.30	1.97	1.96
% Error	20.12	17.91	11.63	15.63	14.53	14.30	10.81	11.98	20.23	18.60
24.61 cm Stimulus Means	20.23	23.02	25.25	27.57	25.63	29.00	32.57	29.26	26.97	25.94
Standard Deviations	6.38	6.75	4.06	7.57	3.78	6.18	6.50	6.38	2.96	3.78
% Error	27.39	22.33	13.88	20.33	12.41	22.65	33.67	24.49	11.63	12.57
49.88 cm Stimulus Means	36.35	43.23	49.00	58.61	53.02	62.58	67.12	60.79	55.11	51.23
Standard Deviations	11.10	18.20	12.20	22.35	16.60	17.20	21.60	11.37	15.75	12.98
% Error	30.01	28.81	17.03	32.12	20.22	30.46	37.39	25.47	20.02	17.52

based on the summary data can be made. Since estimation by the physical units represents a different task than estimation by the verbal unit, it will be discussed separately.

There is a trend for estimates made by the MU to be greater than those for the EU when estimating in terms of physical units. This occurred for EU-MU comparisons in 9 out of 12 cell means. The estimates of the larger two stimuli estimated by the largest unit of measure (7 cm) do not follow this trend. Another finding indicated by the data summary is that estimates for both the MU and EU for the larger stimuli were generally overestimated by the three larger units of measure, and underestimated by the cm unit.

The error scores in Table 1 represent the mean percentage deviations, computed without regard to sign, of estimates from measured size of the stimuli. An examination of error scores for the physical units presents results similar to the comparison of means; no consistent trend occurred between the two classes of Ss. Both the magnitude and error examination suggest that the role of familiarity with a particular unit of measure has little effect on estimations when the units are physically presented and not specified as familiar ones.

Estimates by verbal report using a familiar unit of measure (in. or cm) did not differ between the MU and EU. However, in all cases, estimates verbally reported, using a familiar unit were greater than estimates made of the same stimuli using the corresponding physical unit, e.g., EU estimates were greater when verbally reported in terms of inches than when using the physical inch unit. When error scores are compared with those for the physical units of measure some interesting differences are obtained. For the 8.73 cm

stimulus, the error value for the familiar verbal unit is greater than those for the physical units; on the other hand, the error scores for the larger two stimuli are among the lowest of all units of measure when estimation is in terms of a familiar verbal unit of measure.

Discussion

A hypothesis suggested by the preceding result is that the unit one draws from memory and compares with the stimulus for estimation is some multiple of the smallest basic unit rather than the unit itself, e.g., perhaps 6 in. for the EU or 10 cm for the MU. [It should be noted that the term "basic unit" refers to common usage rather than a physically defined standard unit. For example, the meter, not the centimeter, is the unit of measure accepted by the International Bureau of Weights and Measures; see Huntoon (1965).] This coincides with the experience one has in quantifying his environment; generally, one estimates lengths greater than 1 in. Whether the lengths fall within a prescribed range cannot be here decided but the results do suggest that the memorially constructed unit for length estimation may be greater than the basic unit.

In general, the findings support a conclusion that the estimation of relatively small lengths by MU and EU are not systematically different in terms of estimated magnitude and deviations from measured size. However, there is a suggestion in the results that differences may exist for larger stimuli.

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Note

1. This study was aided by a grant from the Rutgers Research Council.

ERRATUM

Gillooly, W. B. The effect of familiarization instructions on associative latency and learning. *Psychon. Sci.*, 1966, 4 (8), 303-304.—Line 21 of the first column should read H₂: SRF†SIF. On page 304, Noble's m should be read as italicized wherever it occurs.

Effect of figure-ground contrast and contour orientation on the temporal range of apparent movement¹

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The range of interstimulus intervals permitting the detection of apparent movement was investigated as a function of figure-ground contrast of the stimuli and also as a function of the contour orientations of the stimulus figures. It was found that the greatest interval ranges occurred when figure-ground contrast was maximal and when the contours of the figures were parallel to each other. The younger of the two Ss showed wider ranges throughout.

Apparent movement, like backward figural masking, represents a temporal conflict between the conditions of physical stimulation and the phenomenon reported. As is the case with figural masking (Pollack, 1965), physically, two stimuli are presented successively with varying intervals between them. In the case of masking, when detection of the figure to be masked occurs, the subjective phenomenon is of simultaneous exposure of the figures. In the case of apparent movement, a single figure is reported as moving continuously across the visual field.

The earlier investigation of figural masking made it clear that both figure-ground contrast and contour orientation played decisive roles in influencing the range of interstimulus intervals which permitted masking. The greater the contrast of the mask with its ground relative to the target, the wider the range of interstimulus intervals permitting masking. Also, parallel contours of target and mask and the absence of angles within the target widened the interstimulus interval. It is proposed that the same rules apply to apparent movement.

As with figural masking, it is suggested that apparent movement represents the apparent displacement of contours toward each other. Therefore any conditions which would promote contour attraction would be expected to widen the range of interstimulus intervals eliciting reports of movement. Evidence for the effectiveness of figure-ground contrast has been shown not only for figural masking, but also for the concentric circle illusion (Oyama, 1961). Evidence for the effect of contour orientation on contour displacement has been gathered by George (1962), Pollack (1964), and Pollack & Chaplin (1964).

It was expected, therefore, that the range of interstimulus intervals permitting the report of apparent movement would become greater as figure-ground contrast of the stimuli was increased, and that having the contours of the stimulus figures parallel rather than potentially intersecting would also increase the range.

The range of interstimulus intervals was chosen as the dependent variable for two reasons. First, it seemed to offer a sensitive single index for the tolerance limits between which successive stimulation in geographically separate locations would be perceived as a continuous change of position. Second, it offered a dimension which would be comparable to that of figural masking, which it appears to resemble (Werner, 1935). Orlansky (1940) found another form of this measure (cycles per second) to be effective in establishing that figural similarity widens the range of interstimulus intervals in which movement is perceived. The measure is derived from subtraction of the transition threshold between simultaneity and movement from that between movement and succession.

Subjects²

Two adult Ss, a male in his thirties (S_1) and a female in her twenties (S_2) served as trained Ss in all conditions of the experiment.

Apparatus

The apparent movement sequence was produced by using a three-channel electronic tachistoscope (Scientific Prototype Corporation, Model GA). Illumination as measured at the eyepiece by a Macbeth Illuminometer was 5.0 ft. c. for all channels.

Procedure

Six pairs of stimuli were used, providing two contour orientations and three figure-ground contrast values for each orientation. For the parallel contour condition, three pairs of 12.7 mm squares, white, light gray or mid-gray on a black ground, were used. For the non-parallel condition, squares of the same size were used, one pair for each of the three contrast conditions, but they were rotated 45°, appearing as diamonds. The first-presented member of each stimulus pair was mounted so that its innermost point was 6.35 mm to the left of the center of the field, and the second-presented stimulus was 6.35 mm to the right, so that the interstimulus distance subtended, in all cases, a visual angle of 39'40". The vertical extent of each stimulus was 56'22", the maximum horizontal extent of a stimulus pair 2°32'24". Viewing was binocular. A blank black field was presented during the variable interstimulus interval.

The stimuli were always presented for 50 msec. The interstimulus interval was variable in 10 msec. steps from 10 to 150 msec.

Upper and lower apparent movement thresholds were obtained from both subjects for each of the six stimulus

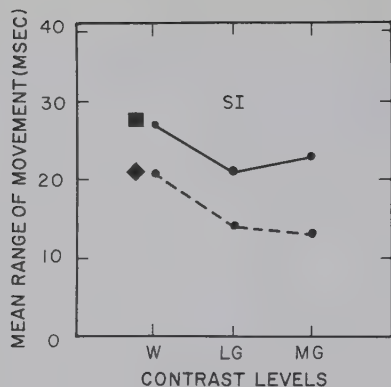


Fig. 1. Range of interstimulus intervals permitting detection of apparent movement as a function of figure-ground contrast of initial stimulus for S_1 (male).

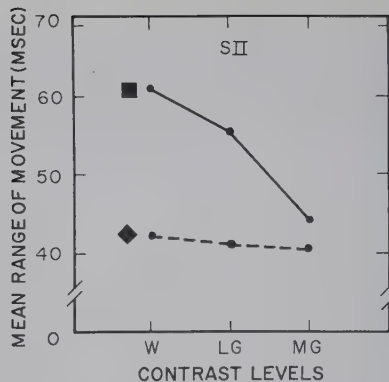


Fig. 2. Range of interstimulus intervals permitting detection of apparent movement as a function of figure-ground contrast of initial stimulus for S_2 (female).

pairs, using the method of limits. Each apparent movement range was based on 32 measures, from two runs, separated by at least a week, of eight ascending and eight descending series, run in counterbalanced order.

In each sequence, Ss were shown instances in which the stimuli were clearly successive, moving, or clearly simultaneous. They were told to say "two" when the figures were successive or simultaneous or "one" when a single figure was seen to move from left to right. Each trial consisted of a series of single sequences of stimulus events.

Results and Discussion

A (3 contrasts) by (2 contour orientations) analysis of variance was performed for each S. Both variables were associated with significant differences in apparent movement interstimulus intervals for both Ss (Orientation— S_1 , $F=35.84$, $df=1/186$, $p<.01$, and S_2 , $F=15.89$, $df=1/186$, $p<.01$; Contrast— S_1 , $F=11.05$, $df=2/186$, $p<.01$ and S_2 , $F=3.26$, $df=2/186$, $p<.05$). The interaction was not significant for either S. (See Figs. 1 and 2). As was expected, the greater the figure-ground contrast of the stimuli, the wider was the range of interstimulus intervals over which movement was reported. At the same time, it is clear that the range was wider when the neighboring contours of the two stimulus figures were parallel than when they were not.

Separate one-way analyses of variance for each orientation for each subject revealed that although the contrast effect was similar in all cases, it was not significant for the diamond orientation in S_2 . It is possible that the effect of orientation is more potent than that of contrast.

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Notes

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2. Acknowledgement is given to Mr. Gene Skoff and Mrs. Jocelyn Marsh who served as subjects and experimenters.

Effects of choice-figure rotation on the visual perception of form¹

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Fifty-six Ss responded in a paper-and-pencil figure-cancellation task to 4-by-4 metric figures. Both random and constrained or "Redundancy-I" figures were used with both rotated and nonrotated choice figures. In terms of speed and accuracy of cancellation, perceptual performance with random figures was better than with constrained, and performance with nonrotated choice figures was better than with rotated. A significant interaction of figure type with rotation indicated that the detrimental effects of choice-figure rotation were especially large when imposed on constrained figures. The effect of choice-figure rotation is interpreted as similar to other "noise" effects that make filtering a necessary part of S's task.

Figure rotation has been identified as one of the "transpositional" parameters that affects the visual perception of form (i.e., a parameter that may be changed without affecting either the uncertainty or the shape of a figure; see Michels & Zusne, 1965). The perceptual performances of both men and animals appear to be improved with the use of rotated figures in tasks that require similarity or dissimilarity judgments (matching responses or discriminations), especially where the judgments are permitted to be based, at least in part, on the cues to sameness or difference provided by the figures' rotations or relative orientations (cf. Arnoult, 1951; 1954; Brown et al, 1962; French, 1953; Hitchcock et al, 1963; Michels et al, 1962).

On the other hand, rotation does not seem to affect ratings of shape for similarity (Small, 1961), geometricity (Zusne & Michels, 1962), or association value (Goldstein, 1961). Figure rotations apparently do not provide cues for these sorts of judgments.

These findings suggest an obvious question: How does figure rotation affect matching responses (or discriminations) when the rotation cannot be used as a cue to sameness or difference—i.e., when the rotational transposition is irrelevant to the correct judgment of sameness or difference in form? The present study was designed to answer this question.

Method

Random and constrained "metric figures" were used, both rotated and nonrotated in a paper-and-pencil figure-cancellation task. These shapes are relatively simple, appearing as solidly dark bar graphs on a white background; they have been described in detail elsewhere (Fitts & Leonard, 1957; Baker & Alluisi, 1962).

The metric figures used in the present study were constructed on the basis of an underlying 4-by-4 cell matrix. The random figures were constructed by random sampling of column heights; i.e., by random sampling from the population of 4⁴ or 256 random 4-column metric figures. The constrained or "Redundancy-I" figures were constructed by sampling column heights at random, but with the constraint that each of the four column heights appeared once and only once in

each figure; i.e., by random sampling from the population of 4! or 24 constrained 4-column metric figures.

A sample of 24 different random metric figures was drawn to serve as target figures in one condition of the study, and the 24 possible constrained figures were used as targets in another condition. These two conditions, the use of random versus constrained or "Redundancy-I" figures, constituted one dimension of the study, rotation versus nonrotation of the choice figures constituted a second dimension of the study, factorial to the first.

The stimulus figures were constructed by using small solid squares (approximately 0.04 cm sq.) produced by a special key on an electric typewriter. The figures were typed directly onto spirit masters and reproduced by spirit duplication as purple-colored forms on one side of 8-1/2 x 11 in. sheets of white paper. The 24 sampled target figures of a given type appeared on each of four different sheets—two sheets (or 48 problems) of rotated choice figures and two of nonrotated figures. The two sheets of a given kind of target and condition of choice-figure rotation were then stapled together to form a subtest, and four subtests were stapled together to form a test. The order of subtests was balanced across test booklets, with 1/4 of the booklets arranged according to each of four orders: 1234, 3412, 2143, and 4321, where 1 and 2 are random-figure subtests, 3 and 4 are constrained-figure subtests, and the even numbers represent rotated-choice-figure subtests.

Each sheet consisted of 24 problems arranged in two columns of 12 problems, the columns' being separated by two heavy lines drawn down the center of the page. Each problem consisted of a target figure on the left and three choice figures on the right; 2-1/2 figure widths separated left from right, and choice figures were separated by unit figure widths. The separate problems, or rows, were also separated by unit figure widths.

The first (left-most) and second choice figures were metric figures of the same type as the target figure, whereas the third choice figure was in all cases an open square equal in over-all area to the cell matrix (approximately 0.64 cm sq.). The task required S to look at the target figure on the left of each row and then to cross out either the first or the second choice figure if it was identical to the target, or the open square if neither of the first two choice figures matched the target. A rotated choice figure, if otherwise identical to the target, was to be cancelled as a matching figure.

All target figures were oriented identically at 0-deg. rotation, i.e., with base horizontal and bars rising. In the "rotated" condition, choice figures appeared at 0, 90, 180, or 270-deg. clockwise rotation, determined at random and independently for each figure; all choice figures appeared at 0-deg. rotation in the "nonrotated" condition. Each sheet of 24 problems called for correct responses of eight cancellations in each of the three possible choice positions, but the order was random and different for each sheet.

The tests were administered to 56 students (25 males and 31 females) in the introductory and developmental psychology classes at the University of Louisville; Ss ranged in age from 18 to 41 years, with a median of 23. None had previously served in any similar study of form perception.

Elapsed time from the beginning of testing was written in 5-sec. intervals on a blackboard in front of the group-testing room by E; the digits were large and clearly visible to all Ss. Elapsed time was recorded by each S at the bottom of each page of the test booklet as he completed that page. Thus, each of the 56 completed test booklets consisted of four cancellation responses (two each with rotated and nonrotated choice figures) for each of the 48 target figures (24 random and 24 constrained), or 192 cancellation responses in all, and also of eight elapsed time recordings—one on each of the eight sheets of the test booklet.

Table 1. Mean Percentage of Incorrect Cancellations (and, in Parentheses, Mean Response Time per Figure Cancellation, in Seconds)

Type of Target & Choice Figures	Choice-Figure Rotation		Mean
	Nonrotated	Rotated	
Random	2.60 (2.632)	4.46 (3.380)	3.54 (3.006)
Constrained	4.98 (3.473)	7.81 (5.071)	6.40 (4.272)
Mean	3.79 (3.052)	6.15 (4.225)	4.98 (3.639)

Results

The mean percentage of incorrect figure cancellations and the mean response time per cancellation are given for each of the four experimental conditions in Table 1. The response times (in seconds) are given parenthetically below the error percentages.

Analyses of variance of these data, based on the 3-dimensional factorial design of figure type (T) by rotation condition (R) by subject (S), yielded similar results with both errors and response times. In both cases, the differences attributable to figure types, to rotation conditions, and to the T-by-R interaction were statistically significant (F ratios of 74.5, 18.8, and 26.1, respectively, in the case of the error scores, and 104.5, 112.4, and 34.8, respectively, in the case of the cancellation times; with df of 1/55 in each case, $p < .01$).

The data of Table 1 indicate that performance with random figures was better (fewer errors and briefer response times) than with constrained figures. Performance with nonrotated figures was also better than with rotated choice figures. The interaction reflects the better-than-expected performance obtained with nonrotated random figures, and the worse-than-expected performance yielded by rotated constrained figures.

Discussion

As was noted in the opening paragraph, the results of a number of studies indicate that perceptual performance is improved with the use of rotated figures, where judgments of similarity or dissimilarity (matching responses or discriminations) are cued or clued by rotations or relative orientations of figures. That is to say, both men and animals will identify quicker and more accurately a "different" figure from a group when that figure is rotated into a different orientation relative to the "same" figures in the group. In such cases, rotation or relative orientation serves as an additional basis for discrimination—figures that are not oriented alike are not the same, even though figures that are oriented alike may still be different.

Rotation was not included to provide a helpful cue or clue to performance in the present study. Indeed, rotation was imposed as an additional source of uncertainty (or variation) that S would have to ignore in making his judgment of sameness or difference of target and choice figures. The data clearly confirm that rotation of the choice figure under these conditions is not an aid to performance; rather, it is detrimental to both speed and accuracy. This is consistent with the interpretation that the rotation serves as a source of undesirable uncertainty or "noise" which S must filter. It should be possible to compare the detrimental effects of this type of noise (rotation) with other types (random cell noise or contour noise; cf. Fitts & Leonard, 1957), and thereby to obtain a better understanding of man's ability to filter noise in his visual perception of form.

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Note

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Distortion of parallel lines in geometrical fields as a function of size of the display

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The illusory distortion of two parallel lines on the Hering, Wundt, and Orbison fields was studied as a function of the size of the display. The Hering and Wundt fields yielded complementary illusions which developed with the size of the display. The Orbison field yielded a lesser amount of illusion and different development.

Marshall & Di Lollo (1963) measured the extent of Hering illusion under comparable degrees of impoverishment in photopic and scotopic vision. The normal illusion was absent at high levels of impoverishment and developed steadily with improvement in viewing conditions. At small visual angles in photopic viewing, a reversal of the normal illusion was obtained, in which the "parallel" lines appeared closer together at the center of the figure. These results were interpreted in terms of local effects of intersecting lines on the magnitude and direction of the illusion.

The present study compares the development of illusory distortion of a pair of parallel lines when set in each of three geometrical fields as a function of the size of the display at a low level of photopic luminance. The three fields were the fanning lines of the Hering figure; its converse, the Wundt figure; and the concentric circles of the Orbison figure (Orbison, 1939). Since the Wundt and the Orbison figures have been regarded as inducing illusory effects that are complementary to those of the Hering figure, complementary courses in the development of these illusions may also be expected as viewing conditions are improved.

METHOD

Apparatus

(a) *Stimulus figures.* Two horizontal brass bars 18 x .25 x .25 in., painted black, were fixed at their centers, 4 in. apart, on a vertical board 18 x 18 in. The ends of these bars could be brought together or made to diverge by means of a worm device operated by E at the rear of the apparatus. Background lines, .25 in. wide, were printed in black ink on white non-glossy cards, 18 x 18 in., which could be inserted behind the horizontal bars on the vertical board. The card for the Hering figure consisted of seven lines, radiating from a central point, to make angles of 20°, 40°, 60°, 90°, 60°, 40°, 20° with the horizontal bars when these were set horizontally, straight and parallel. In the corresponding card for the Wundt figure, seven lines from a point 2 in. above the center of the upper bar and seven lines from a point 2 in. below the center of the lower bar made the same seven angles of intersection with the parallels and termin-

ated midway between them. The card for the Orbison figure had a central black circle of .5 in. diameter and a set of concentric circular bands .25 in. wide and 1 in. apart.

(b) *Acuity target.* A Snellen "E" of 1.65 x 1.65 in., having limb width of 0.33 in. was set on a white non-glossy card 18 x 18 in. A second acuity target consisted of a similar card with a Snellen "E" having 0.25 in. limb width.

(c) *Display.* The stimulus figure was focused on an opal glass screen at the rear of a bellows camera which was set in a partition between two dark rooms. The vertical board could be set at one of five distances in front of the camera by sliding it to marked positions along an 18 ft. table. At these five distances the images of the stimulus pattern on the opal glass screen were square shapes with sides of .75, 1.0, 1.4, 2.2, and 3.9 in. respectively. The luminance of the display to the S was .5 footlamberts.

Subjects and Procedures

The Ss were 12 University students with at least 20/20 vision and no pronounced astigmatism. They were randomly allocated to an experimental and a control group of six Ss each. They sat in a feebly illuminated room facing the display which, when using a chin rest, was at eye level. Each S sat at a distance from the screen at which he could name the orientation of the larger "E" acuity target with an accuracy of four out of four or seven out of eight correct judgments but was not equally successful with the smaller one. In the display these targets had limb width of .014 and .011 and yielded viewing distances ranging from 59 to 84 in. The three figures and the five sizes of display made 15 combinations; these were presented randomly to each S who was required to say when the lines, adjusted by E from different prescribed starting positions, became parallel. The six Ss in the control group had essentially the same treatment except that the three background fields were replaced by a non-glossy white card of the same dimensions.

RESULTS AND DISCUSSION

Each S made six settings of the horizontal bars for each of the three figures at each of the five sizes of the display. These six scores, representing the separation of the ends of the horizontal bars on the vertical board, were averaged to give a score for each S who thus had 15 scores: one for each size-figure combination. Average scores are shown in Fig. 1.

At the three largest sizes of the display the characteristic illusion associated with each background field was obtained, the bars being set more widely apart at

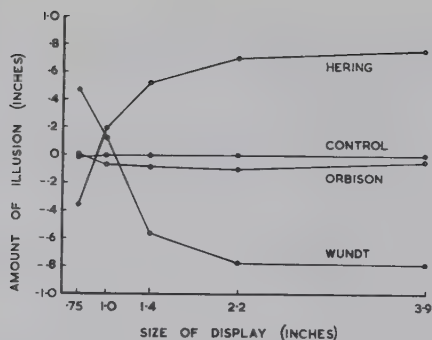


Fig. 1. Amount of illusion as a function of the size of the display. The amount of illusion is the average separation of the bars at the edge of the display less their separation when parallel.

the ends in order to appear parallel in the Hering illusion, but closer together in the case of the other two. The Wundt and Hering illusions developed symmetrically with increments in the size of the display; the Orbison figure yielded a lesser amount of illusion and a different course of development.

These results are more easily interpreted in terms of local influences at the intersections of lines, than in terms of overall configurational effects (Marshall & Di Lollo, 1963). In the Wundt and Hering figures the apparent displacement of segments of the horizontal lines may be due to an illusion arising from intersection of lines set at acute angles (Titchener, 1910). These local effects are reduced as the intersections become less clearly seen with reduction in the size of the display. In the Orbison figure here used, the number of concentric circles should have been sufficient to generate a field of forces but the angles formed by the horizontal lines and the background concentric

circles were considerably greater than the acute angles in the other two figures. The process of overestimation of acute angles was hence less effective.

A reversal of the normal illusion was obtained in the Wundt and Hering figures at the smallest size of the display ($p < .01$). Some trials suggest that this effect is not obtained when the most slanted radial lines (20°) are removed from the inducing fields. This result supports the interpretation that the negative illusion arises from an assimilation of the end segment of a horizontal line with the end segment of the most slanted radial lines when, at a given level of luminance, the distance between them at the furthest point is below a certain critical value of angle to the eye. Such assimilation may arise either as a result of the acuteness of the angle itself (Adam, 1964) or, as here, as a result of the smallness of the angle subtended to the eye by the relevant section of the figure.

The development of the illusion and the points of transition from negative to normal illusion appear to depend on the smallest size of resolvable detail. Because of the level of luminance employed, the size of minimum resolvable detail at the highest level of impoverishment was intermediate in the present study between that possible under the photopic and scotopic conditions of an earlier experiment (Marshall & Di Lollo, 1963), and the amount of negative illusion was also intermediate.

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Adaptation to prismatic displacement as a function of the amount of available information

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The amount of information available during a pointing response while wearing displacing prisms was varied by allowing the arm to remain free or by constraining it to a track. There was significant adaptation in both conditions and the adaptation for the unconstrained or high information group was significantly greater.

The importance of knowledge of errors in adaptation to prismatic displacement has recently been in dispute. Held has maintained (Held & Gottlieb, 1958; Held, 1961) that such information is unnecessary and offers as evidence the fact that his Ss adapt while their arms remain strapped to a pivoted paddle. With the arm thus constrained there is no opportunity for knowledge of response errors induced by the optical distortion.

Other investigators (Weinstein et al, 1964) contend that adaptation results from information gained about the nature of the distortion from knowledge of errors available in one's own responses. A recent study by Howard, Craske, & Templeton (1965) seems to show that information about the nature of the distortion, even in the absence of a response, can produce adaptation to displacement.

To clarify the role of available information in adaptation, this study was undertaken.

Method

Twelve right handed students enrolled in an elementary psychology course participated as part of their course requirement. Each served under only one condition.

The apparatus was a table (5 ft. x 42 in.) with a clear Plexiglas top and a removable cardboard cover. At one end of the table was a U shaped notch for the S's head. A bite board served to hold S's head in place. A yardstick was attached to the underside of the table top, parallel to and 18 in. from S's frontal plane.

While in the apparatus, S wore 25 diopter wedge prisms which displaced the target 4.5 in. The target, which was placed above the yardstick in the center of the table, was a wedge of wood with a darkened edge.

For adaptation session the cover was removed from the apparatus.

The high information group pointed 50 times to the target. They could clearly see any errors in localization.

The low information group had their right hand constrained on a track. The angle and inclination of the track had been determined from measurements taken

on three pretest Ss, so that the motion of the hand along the track closely approximated the motion of the hand in freely pointing to the target. The track was mounted in the apparatus and the target placed at one end. S moved his hand up the track 50 times with the instruction "Move your hand up the track just as though you were pointing at the target."

With their hands constrained to the track the low information group could make no errors, hence they do not have the additional informational input available to the high information group who do have this feedback.

All measurements were taken with the table cover in place. This blocked S's view of his hand. Three pre-measures with prisms in place were taken. Following adaptation three adaptation measures were taken with prisms in place and three aftereffect measures were taken with the naked eye.

Results

The results are summarized in Table 1.

The adaptation and the aftereffects are significant for both groups ($p < 0.02$). The difference between the high information and low information groups is significant at $p < 0.02$ (Mann-Whitney U test) for both the adaptation and the after effects.

Discussion

In the low information condition where the hand was constrained to the track and no information about the nature of the distortion is available from knowledge of response errors, there is still significant adaptation. This essentially verifies Held's contention that knowledge of errors is not necessary for adaptation. However the adaptation is approximately twice as large in the high information condition where this information is available, thus it appears that knowledge of errors can be used in adaptation.

A simple information processing model can not explain the adaptation in the low information condition, while a simple re-reference model cannot explain the increment in adaptation in the high information condition. These data suggest that both of these processes act simultaneously during the course of adaptation.

Table 1. Adaptation in inches

	Adaptation	After effects
High information	3.27	2.37
Low information	1.52	1.27

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Taction thresholds for short pulses¹

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Absolute taction thresholds for short pulses are determined for different pulse-repetition rates and sizes of contactor. It is shown that cutaneous mechanoreceptors summate energy increments resulting from an increase in repetition rate and in the size of the contactor. Discrepancies between measurements obtained using short pulses and sine waves are discussed. The results are consistent with the hypothesis that a duplex mechanism of mechanoreception exists over most of the body surface.

The absolute thresholds for vibration, measured as a function of sinusoidal frequencies, have been established for human skin (Békésy, 1939; Hugony, 1935; Knudsen, 1928; Setzepfand, 1935; Sherrick, 1953; Verrillo, 1963). The general shape of the function is U-shaped with a minimum in the region of 250 cps. Variations in threshold as a function of contactor size (Verrillo, 1963) and for a variety of temporal patterns of the stimulus have also been determined (Verrillo, 1965). Since the frequency characteristics of the threshold is determined not only by events per unit of time, but also by the rise time and duration of the individual event, it becomes important to examine the threshold function using short pulses of constant rise time and pulse width in lieu of sinusoidal vibrations. A number of different contactor sizes were tested to examine the effects of spatial summation.

Apparatus and Procedure

The apparatus and experimental procedures used in this experiment are described in an earlier publication (Verrillo, 1965). Rectangular electrical pulses of 1.0 msec. duration were passed through a manual attenuator and power amplifier and fed to a vibrator. The response of the vibrator to this signal was a highly damped oscillation with a width of 1.0 msec. and 1.0 msec. rise time.

The Ss were tested in a booth that provided isolation from building vibrations and wore earmuffs to eliminate sounds from the vibration. The site of testing was on the fleshy pad over the first metacarpal (palmar) of the right hand.

Threshold as a Function of Repetition Rate

Absolute taction thresholds were determined as a function of pulses repeated at the rate of 1, 2, 4, 9, 17, 32, 64, 130, and 200 per sec. Interference between pulse transients made it impossible to test at higher rates. In order to assess the effect of contactor area, four areas were used: 0.005, 0.02, 0.32, and 2.9 cm².

The experimental results shown in Fig. 1 are plotted as a function of pulse repetition rate. Each data point represents the median of three testing sessions using four Ss. Curves have been drawn through some of the data to indicate the slope. It is evident that for the two

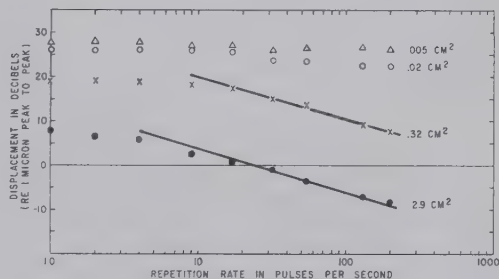


Fig. 1. Vibrotactile thresholds as a function of pulse repetition rate with contactor area as parameter.

large contactors (0.32 and 2.9 cm²) the skin is summing the energy over pulse rate. The slope is -3 dB per doubling of the repetition rate. This curve is consistent with the slope predicted by Zwischlocki's theory of temporal summation accounts for 3 dB of the 12 dB slope found below 250 cps in the threshold curve for sinusoidal vibrations (Verrillo, 1963).

It is also evident that for small contactors (0.02 and 0.005 cm²) there is no summation over pulse repetition rate. This flat curve was also observed when thresholds using small contactors were plotted as a function of sinusoidal frequencies (Verrillo, 1963). The difference in threshold response between large and small contactors has been explained by a dual-receptor hypothesis of mechanoreception in cutaneous tissue (Verrillo, 1963; Verrillo, 1966). This hypothesis states that one receptor system summates energy as frequency increases while the other functions independent of frequency. The data in Fig. 1 support this hypothesis.

Threshold as a Function of Contactor Size.

The data are replotted in Fig. 2 as a function of contactor size with repetition rate as parameter. The

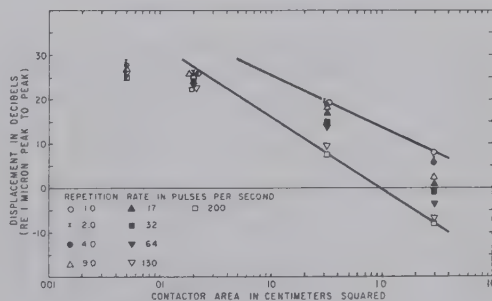


Fig. 2. Vibrotactile thresholds as a function of contactor area with repetition rate as parameter.

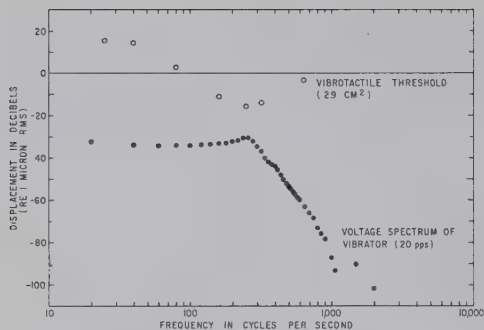


Fig. 3. Voltage spectrum of short pulses repeated at the rate of 20 per second and the vibrotactile threshold for a 2.9 cm² contactor.

data show that the skin receptors summate energy over the area of the stimulus at all pulse repetition rates. Comparison of these data with results of a similar experiment in which sinusoidal frequencies were used (Verrillo, 1963) reveal a very obvious difference. For sinewaves no spatial summation occurs for the lowest frequencies (25 and 40 cps) whereas the pulse data in Fig. 2 show spatial summation even at 1 pps. This at first appears to be inconsistent with the duplex hypothesis which would require that one population of receptors be independent of spatial and temporal changes.

In order to examine this result more closely, spectral analyses of the pulses were made at three repetition rates. This analysis showed that the envelopes of the

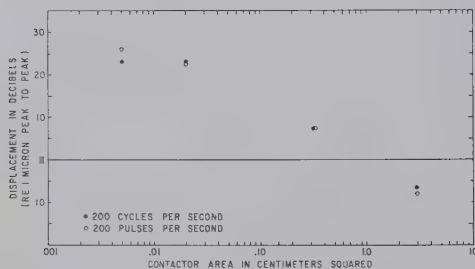


Fig. 4. Vibrotactile thresholds for sinusoidal vibrations (200 cps) and for short pulses (200 pps) plotted as a function of contactor area.

pulse spectra are essentially flat to 250 cps where there is a slight rise and then a steep cut-off to 1000 cps. A pulse spectrum, produced by a repetition rate of 20 pps, and the absolute vibrotactile threshold for a 2.9 cm² contactor are shown in Fig. 3. The region of greatest sensitivity for the skin (250 cps) is coincident with those frequency components of the pulse having the greatest amplitude. This is substantiated further by comparing the threshold data for 200 cps with the corresponding results of a repetition rate of 200 pps (Fig. 4). Although the slopes in Fig. 2 for 1 through 32 pps are of low repetition rate, the pulses have strong components in the region of 250 cps which determine the threshold and thus the downward deflection of the curve.

Another discrepancy between sinusoidal and pulsed data deserves mentioning. The slopes in Fig. 2 vary about -4 dB per doubling of the area while the corresponding sine-wave slopes are about -3 dB per doubling (Verrillo, 1963). This difference may be attributed to the fact that the curves for the sinusoidal results are based on four data points, while the curves in Fig. 2 are based on but two points. Referring again to Fig. 4 it can be seen that when the same number of points are used for both sinusoidal and pulsed data, the slopes are identical. It is evident that the threshold for vibration decreases in direct proportion to the stimulus area regardless of the shape of the individual stimulus event.

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Note

1. This work was supported by a contract between the U. S. Office of Naval Research and Syracuse University.

The effect of the orienting reaction on disjunctive reaction time¹

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Eighty Ss performed a visual or auditory disjunctive reaction time (DRT) task in which some of the task stimuli were preceded, at irregular intervals, by an intense visual or auditory "orienting stimulus." Initially the orienting stimuli impaired speed of response, but on subsequent presentations produced shorter DRTs than when no orienting stimulus was given. It is suggested that the warning signal used in RT experiments may influence performance not only as a result of the information it carries, but also because it may elicit an orienting reaction.

In a simple RT experiment shorter RTs are generally found when a warning signal is used than when no warning is given, provided that the interval between the warning and task stimuli is constant. If the warning interval is irregularly varied, no difference is found (Hermelin & Venables, 1964; Klemmer, 1956). An apparent exception to these results is found in a study by John (1964). He showed that the speed of response to auditory task stimuli was facilitated when they were preceded, at irregular intervals, by an extraneous visual stimulus. It is possible that the conflicting findings are partly due to the confounding of two properties of the warning signal. Although intended to inform the S of the impending task stimulus, the warning signal may also act as an "orienting stimulus," giving rise to the orienting reaction, which has been shown to affect certain sensory and perceptual processes (e.g., Martin & Edelberg, 1963; Sokolov, 1963).

A test of the hypothesis that the orienting reaction, which results from the presentation of the warning signal, improves performance in an RT experiment would require that the informational properties of the warning signal be eliminated, so that it would serve merely as an "orienting stimulus." In the present experiment the temporal relation between the warning (now orienting) stimulus and the task stimulus were arranged to be so unpredictable as to minimize the informational value of the former. The effects of such non-informational auditory and visual stimuli on the speed of disjunctive response to auditory and visual task stimuli were studied.

Method

The Ss were 80 male volunteers from the Armed Forces. Their ages ranged from 17 years to 47 years with a mean of 23.7 years.

S was seated facing into a dimly illuminated wooden cubicle. The visual task stimulus consisted of a 1/5 sec. flash of red or green light projected onto a screen situated at eye-level at a distance of 3 ft. from S. The auditory task stimulus was a 1/5 sec. 80 dB 500 cps tone presented to S's right or left ear through earphones. The response unit consisted of two button-operated microswitches mounted 2 in. apart on the arm of S's chair. A 1/5 sec. burst of 70 dB white noise delivered to both ears served as the auditory

orienting stimulus, and a 1/5 sec. burst of flashing white light was the visual orienting stimulus. The light, from a source situated directly above S, had a frequency of 1000 flashes/min. and a peak intensity of 0.21 million candlepower.

Ss were randomly assigned to four equal groups, each group receiving one of the four possible combinations of auditory and visual orienting and task stimuli. The experiment consisted of three parts, run consecutively for all groups. In parts I and III, the two control series, each S received 20 randomly ordered blank trials (no orienting stimulus). In part II each S received four successive blocks of 10 trials, each block consisting of four critical trials on which the orienting stimulus preceded the task stimulus by 0, 1, 2, or 4 sec., four blank trials, and two trials on which the interval between the orienting and task stimuli was 6 or 8 sec. The results for these last two trials, which were designed to make the orienting and task stimuli appear more independent, are not included in the analyses. The order of orienting stimulus-task stimulus intervals used on the four critical trials was balanced over blocks and Ss according to a Latin square design. The interval between successive task stimuli was 8, 10, or 12 sec., randomly ordered.

Ss were instructed to respond to the task stimuli by pressing the appropriate button as quickly as possible. Half the Ss in each of the two groups receiving visual task stimuli were told to press the right button for a red stimulus, the left button for a green stimulus; the remaining Ss had the reverse combination. Ss receiving the auditory task stimulus were instructed to respond to a tone in the left earphone by pressing the left button, and to a tone in the right earphone by pressing the right button. For half these Ss the earphones, but not the instructions, were reversed.

Results

The control series in parts I and III of the experiment were designed to detect effects of practice or fatigue. The average control DRTs indicated a general decrease, from part I to part III, in response speed for one group, and an increase for the other three groups. Two-tailed t-tests showed none of these changes to be significant.

For each group, the results of part II showed the average DRT for the four critical trials to be longer than that for the blank trials in Block 1, but the relation was reversed in later blocks. An analysis of variance showed this interaction between critical vs. blank DRT and blocks to be significant ($p < .001$). These results, averaged over groups, appear in Fig. 1.

The average DRTs for the four orienting stimulus-task stimulus intervals and for the blank trials are shown in Fig. 2. On the basis of the differential effect displayed in Fig. 1, the results shown are for Block 1 and the average of Blocks 2, 3, and 4. The results for the 0 sec. interval for the group receiving auditory orienting and task stimuli have been omitted from the analysis.²

Discussion

Comparison of the average DRTs for the critical and blank trials shown in Fig. 1 indicates that the occurrence of the orienting stimulus impaired speed of response in Block 1. It seems likely that this initial (Block 1) impairment was due to interference caused by the occur-

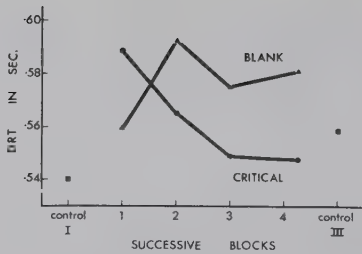


Fig. 1. Meandisjunctive reaction times for the critical and blank trials for each block in part II, and for the control series in parts I and III.

rence of "novelty reactions," an effect previously demonstrated by Favreau (1964). It will be seen in Fig. 2 that the initial impairment was generally greater when the orienting stimulus was auditory, especially at the 1 and 2 sec. intervals. Although both orienting stimuli were intense, it is generally agreed (Sokolov, 1963) that auditory stimuli, per se, are likely to elicit stronger novelty or orienting reactions than are visual stimuli. The clearest evidence for facilitation was seen when both orienting and task stimuli were visual, this effect being most noticeable at the 1 and 2 sec. intervals.

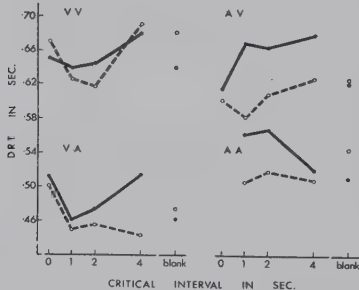


Fig. 2. Disjunctive reaction time as a function of interval between orienting and task stimuli for Block 1 (solid line) and the average of Blocks 2, 3 and 4 (broken line) for each group. The corresponding mean DRTs for the blank trials are also shown. A denotes auditory, V denotes visual; the first letter of each pair refers to the orienting stimulus, the second letter refers to the task stimulus.

Although every attempt was made to prevent S from associating the orienting and task stimuli, it is possible that the facilitation resulted from Ss regarding the orienting stimulus as a warning signal, thereby gaining some small amount of information as to the occurrence of the task stimulus. A more plausible interpretation, however, may be based on the progressive habituation of the orienting reaction. Thus the increase in arousal underlying the orienting reaction was initially sufficiently large to interfere with performance, but subsequently diminished until its effect was one of facilitation. Evidence which may be taken as support for this interpretation has been obtained by Fuster (1958) who stimulated the reticular formation of monkeys performing a visual discrimination task. He found that the shortest RTs were associated with medium levels of stimulation, higher levels resulting in poorer performance.

It is concluded that the effect of an orienting stimulus on DRT may be one of impairment or facilitation depending on the degree of habituation of the resulting orienting reaction. Inasmuch as a warning signal in an RT experiment may elicit an orienting reaction, its effect on performance may not be wholly determined by its informational value.

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Notes

1. This research was supported by a grant (9425-10) from the Defence Research Board of Canada to Dr. Dalbir Bindra.
2. The average DRT on these trials was almost twice that for the other critical intervals. It was found that in this condition Ss had difficulty determining in which ear the task stimulus occurred. For this reason the results were not included in the analysis.

The prediction of perceptual-motor learning from independent verbal and motor measures¹

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Forty male college students were administered motor and verbal pretests and were given learning trials on a criterion task which required both motor and verbal skills. The pretests were employed as predictors to determine the relationship of verbal and motor abilities to early and late stages of perceptual-motor performance. It is suggested that verbal comprehension is more important early in perceptual-motor learning while motor skill is more critical in later learning.

Several writers (James, 1890; Broadbent, 1958; Welford, 1958) have discussed the possibility that different components or abilities which contribute to learning early in practice may be different from those which facilitate later learning. Of particular interest has been the question of how so-called "verbal" and "motor" components interact with one another during the course of acquisition and later mastery of a task. Along experimental lines, Fleishman & Hempel (1954) reported that non-motor factors, e.g., visualization, and spatial relations, contributed 46.1 per cent of the variance in the scores during the first stages of practice on a coordination test while motor factors, e.g., psychomotor coordination, and rate of movement contributed only 29.5 per cent. During the final stages of practice, non-motor factors accounted for 10.5 per cent while motor factors accounted for 74.5 per cent.

The study reported here involved the use of independent verbal and motor measures to predict Ss' scores on criterion task trials. The hypothesis under test was that the verbal predictor would best describe learning in early criterion task trials while the motor predictor would gain in predictive strength as learning progressed.

Method

The Ss were 40 male undergraduates at the University of Illinois. The apparatus employed as the motor test was the Two-Hand Coordinator (the THC is described and pictured in Gagne & Fleishman, 1959). All Ss were first given 15 1-min. trials on the THC with a 15 sec. intertrial interval. The score given each S was the mean time on target for all 15 trials. For the verbal test, a Memory Drum was used. The list of items put into the drum was ordered in a way that would correspond as closely as possible to the design of a 14-unit T-maze. To fulfill this requirement, 14 CVC nonsense syllables were selected. Next the syllables ZEB and BEP were randomly paired with the 14 syllables, making the list as follows: KEV-ZEB, SOF-ZEB, BIM-BEP, LAZ-BEP, COR-BEP, etc. The Ss were given 15 trials with the same list, and were allowed a 15 sec. intertrial interval.

The score was the mean number of syllables and associates correctly anticipated for all 15 trials.

The construction of the criterion task involved a modification of the THC, and was designated the Modified THC. The motor, circular plate, and follower arm were removed from an intact THC. A 14 choice point T-maze was cut into a 5/8 in. plywood board which was, in turn, mounted and fastened on top of the THC. A 3/8 in. diameter peg was mounted in the moving parts of the THC such that by alternating the movements of the handles, the peg could be made to traverse the alleys of the maze from start to finish. A wire was coiled around the peg and the end was attached to one pole of a 6-volt dry cell battery. Electrical contacts were wired to all the choice points and blind alleys of the maze and connected in such a way that when the moving peg touched any choice point, contact was made and a green light came on. Similarly, the choice of a blind alley gave a red light. The Ss were able to learn the maze only by means of the information gained from the red and green lights. Both lights were installed on a panel which entirely covered the maze; thus the S was unable to see the peg or the maze as he operated the two handles. A total of 15 Modified THC trials were administered. A S's score on a trial was the time required to traverse the Modified THC from start to finish.

Results

The correlation between the mean time on target for the motor scores and mean correct for the verbal scores was .04, not statistically significant. This result indicates that the verbal and motor measures tap independent ability traits, each of which accounts for separate and additive amounts of variance in the Modified THC trial scores. In order to examine the relationship of the motor and verbal predictors with the Modified THC trial scores, an analysis developed by Tucker (1960) was employed. The first step was to carry out a principal axis factor analysis on the Modified THC scores. Factor A accounted for 71 per cent of the variance in the matrix while factor B accounted for 13 per cent. The remaining factors extracted each accounted for less than 5 per cent of the variance and thus were deleted from the analysis. The loadings of trials on principal factors A and B is shown in Fig. 1. Examination of Fig. 1 leads one to believe that differential loadings of trials on the two factors exists, since the trial loadings on factor A increase sharply and then level beginning with trial 3 while those on factor B show a consistent decrease throughout.

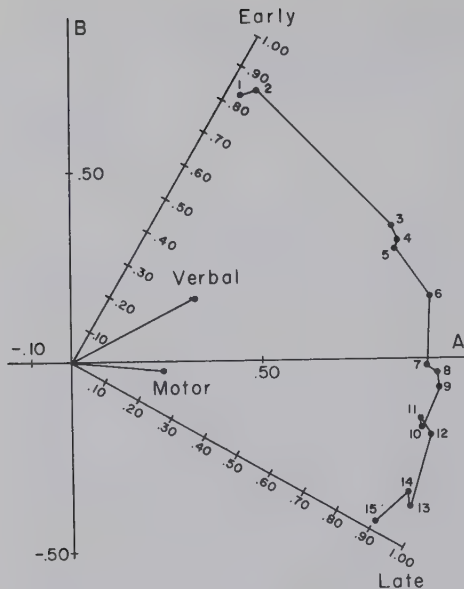


Fig. 1. Inter-factor plot of rotated factor loadings with projections of the motor and verbal predictors.

Figure 1 also shows the rotation made on factors A and B. The new factors can now be appropriately identified as an Early and a Late factor. The "Early" and "Late," of course, refers to the fact that the early Modified THC trials load highest on the Early factor while the late trials load highest on the Late factor. The final step in the analysis was to obtain the

correlation of the motor and verbal predictors with the rotated factors. The result showed that the motor predictor was correlated .23 with the Late factor and .12 with the Early factor whereas the verbal predictor yielded a correlation of .29 with the Early factor and one of .19 with the Late factor. The projection of the motor and verbal predictors onto the inter-factor plot of rotated factor loadings is presented in Fig. 1. With $df=40$, a critical r of .257 is required for significance at the .05 level of confidence. The verbal predictor was significantly related to the Early factor but not to the Late factor. The motor predictor fell short of a significant relationship with the Late factor, but yielded a numerically higher correlation to the Late as opposed to the Early factor. While all the correlations presented are moderate in magnitude, the results depict a trend in the direction predicted by the research hypothesis.

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Note

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Process of component and pattern learning¹

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The process of discrimination among stimuli on the basis of cue patterns or their partially relevant subsets was traced by independent tests spread over the course of learning. While the cue subsets seemed most important during early trials, the full patterns rapidly started dominating as discrimination accuracy on the basis of common subsets actually decreased.

In order to answer some questions raised by mathematical learning theorists, the present experiment traced component and pattern conditioning by the use of tests at various learning stages. The stimuli involved both common cues and common patterns of cues, and perfect discriminations could be made only by the use of highest order patterning.

Unfortunately, the full array of learning blocks that had been planned at the outset could not be completed. The design of the experiment necessitated the use of very large numbers of Ss and the subject-supply during the year of running was exhausted before completion of all conditions. At the end of the year, the apparatus was dismantled because of a change in the affiliation of the principal investigator.

Method

The learning and test stimuli may be seen in Fig. 1. The responses associated with the learning stimuli, by paired-associates with anticipation, were VOP, GAK, FUH, TEF, CYQ, ZIR, QAR, and BYM.

The Ss were run in threesomes and forced to respond at each choice point. That is, during learning, all three Ss had to respond to each stimulus before its syllable

appeared in association with it. Then, the stimulus-response pair remained in view until all Ss who had responded incorrectly to the stimulus alone corrected their responses. The intertrial interval was 2.2 sec.

On test trials, the figures designated i to t in Fig. 1 remained in view without associated responses until all Ss responded.

Learning for one set of Ss consisted of a single block of learning trials (all eight learning stimuli in Fig. 1) and their paired syllables; a single test trial followed. No further tests nor learning trials were given to these Ss because of the desirability of avoiding the potentialities for contamination of learning set by the test. For convenience of reference, the Ss shall be considered in groups as follows: Group II was shown figure i as the test, Group Ij was shown j, and so forth through Group It. All test figures occurred an equal number of times over the groups.

For other Ss, precisely two learning blocks were followed by a single test and nothing else. Again, there were Groups III, IIj, etc. and all test figures occurred equally frequently. In addition, since paired-associate trials were structurally identical to test trials during the interval preceding occurrence of the responses, the first trial of the second block could be regarded as a test in the same way as the tests for Groups II, Ij, etc. The test figure was then a stimulus of full cues. To allow for this source of data, all learning stimuli occurred first an equal number of times during the second block. Using a similar coding, Group Ia contains those Ss who received two (or more) learning blocks and who were shown a as the first stimulus during their second block.

Similarly, some Ss were run for exactly three learning blocks and others for exactly four blocks. A single test trial followed learning in each case. None were run for more than four blocks for the reasons given earlier, although the original intention was to run groups for more and more blocks until a criterion was met.

Twenty-four threesomes were run for each of the fixed block lengths (1 to 4). The number 24 is a multiple of 12 (the number of test figures) and 8 (the number of learning stimuli), and allowed equal occurrences among test figures after each learning block as well as among the learning stimuli in their role as test figures. Thus, Groups II, Ij, III, etc. contained six Ss each, Groups Ia to Ih—27 each, Groups IIA to IIH—18 each, and Groups IIIA to IIH—9 each.

Results and Discussion

For convenience of reference, the differentiating stimuli in figures i to n (Fig. 1) shall be referred to as components, the stimulus arrays in figures o to t

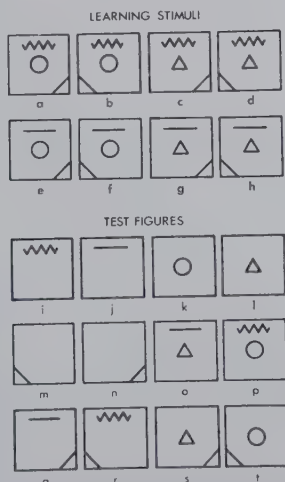


Fig. 1. The Learning Stimuli and Test Figures.

Table 1. Relative Frequencies of Appropriate Responses

		Learning Block Preceding Test											
		1			2			3			4		
Test Figures													
		Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.
i-n(Components)		.500	.611	.500	.750	.500	.722	.500	.639	.500	.639	.500	.639
	Using Comp.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.
o-t(Intermediate Patterns)		.250	.306	.528	.250	.375	.528	.250	.361	.417	.250	.320	.472
	Using Comp. & Inter. Patt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.	Chance Expect.	Obt.
a-h(Full Patterns)		.125	.208	.204	.125	.226	.271	.125	.211	.278			

as intermediate patterns, and the arrays in the learning stimuli (a to h) as full patterns. Table 1 contains a summary of proportions of appropriate responses to the various test figures. In addition to the obtained proportion, both the proportion expected if responding were purely random and that expected if the cues used in response determination were a proper subset of the array actually available are shown.

The case of proportions based on fewer cues than the array available will be illustrated by a, for which the proper subsets consist of both components and intermediate patterns. Assuming equal likelihood of sampling component or intermediate pattern, the estimated probability of an appropriate response to a as a test following Block 1 is $.5(.611/4) + .5(.528/2) = .208$, where the .5 multipliers represent probabilities of component and pattern selection, the numerators the relative frequencies of appropriate responding to component or pattern, and the denominators the number of appropriate responses for the particular cue configuration, only one of which is appropriate to the full pattern of a.

The data in Table 1 would seem to indicate that components and intermediate patterns account for nearly all the initial learning, but that full pattern learning begins to show itself rather rapidly. Note that the relative frequency of appropriate responses to full patterns after Block 1 is completely accounted for by assuming only use of components and intermediate patterns. But, the tests on figures a-h following subsequent blocks show increasing tendencies to respond appropriately at a rate higher than could be expected by the use of anything less than full patterns. (The relative frequencies for full patterns as tests correspond, as expected, with the obtained proportions of correct anticipations to all learning stimuli over Blocks 1 to 4 which are, respectively, .156, .215, .269, and .340.) And, concomitantly, starting with Block 2, the proportions of appropriate responses to i-n and o-t decrease regularly over the remaining blocks with only one exception.

The results of Binder & Feldman (1960) may be used to estimate the probabilities of appropriate responding to components and intermediate patterns after a criterion is reached in identifying full patterns. Their Group I-E run involved eight learning stimuli identical to those of the present experiment. Learning was again paired-associates by anticipation, but fixed anticipatory periods were used and tests were given only after a criterion of two consecutive perfectly anticipated blocks was reached. The obtained proportions of appropriate responses were .943 to components and .829 to intermediate patterns.

The proportions of appropriate responses to components and intermediate patterns shown in Table 1 do not seem headed anywhere near those magnitudes, even though the learning of full patterns shows regular increments. There would seem two principal contenders to account for the patterning of results. First, except for the results of preliminary exploration of stimuli, components and intermediate patterns are not learned until the full patterns are adequately learned—perhaps later learning involves a closer examination of stimulus characteristics and the association of responses to cue subsets. And second, identification of appropriate responses to components and intermediate patterns is mediated by prior identification of full cue response. That is, when, for example, a test like t is shown, the S fills in missing details and responds accordingly. This second hypothesis implies a less direct association between responses and components or intermediate patterns in general, although it could certainly allow for some associations to subsets which are as immediate as those to full patterns.

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Note

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Performance of preschool children on three discrimination shifts¹

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After learning an initial two-dimensional discrimination, preschool children were given reversal (RV), intradimensional (ID), and extradimensional (ED) shifts. RV and ID shifts were learned faster than ED shifts, a finding contradictory to the mediational theory of Kendler & Kendler (1962).

A mediational theory of discriminative learning in which the mediational process is more readily available to adults than to young children and animals has been presented by Kendler & Kendler (1962). Lending support to this formulation are the results of experiments comparing reversal (RV) and extradimensional (ED) shift performance. While it has been found consistently that adult Ss learn RV shifts faster than ED shifts (Isaacs & Duncan, 1962; Kendler & D'Amato, 1955), the results of other experiments suggest that young children (below approximately 6 yr.) learn ED shifts faster than RV shifts (Kendler & Kendler, 1959; Kendler, Kendler, & Wells, 1960; Marsh, 1964; Tighe & Tighe, 1965). Eimas (1965) recently has made a criticism which bears upon the methodology of these latter four studies. All have employed ED-shift procedures in which the relevant dimension of Problem 1 was made constant within trials in Problem 2. Perhaps a mediational response is not elicited strongly by a stimulus dimension unless the dimension is variable within trials. An RV-ED shift difference in favor of mediational theory might not be expected unless this condition were met. The suggestion is that the conclusion of a developmental change in the mediational process may not be warranted.

The present experiment compares RV and ED shift performances in preschool children. An ED-shift procedure is used in which the relevant dimension of Problem 1 becomes variable-irrelevant in Problem 2. An intradimensional (ID) shift condition is included. A comparison of ID and ED shift performance provides the more appropriate test of mediational theory since sources of instrumental response transfer are eliminated.

Method

The discriminative stimuli consisted of three-dimensional objects differing in form (triangle, circle, square, T) and color (red, green, yellow, blue). Each of these stimuli measured 2-3/4 in. in both length and width and 1/2 in. in height. The stimuli were mounted on 3-3/4 x 3-3/4 in. gray blocks. Each block was halved along the frontal plane with the two halves joined by a hinge. The interior of each block contained a marble well which was exposed upon displacement of the top half of the

block. The two stimuli to be discriminated were placed 10 in. apart on a gray turntable. A screen in the center of the turntable prevented the S from observing the E as each trial was prepared.

All Ss were given two-choice, simultaneous discriminations in Problem 1 involving two component values of each of the dimensions on which the stimuli varied. One of these dimensions was relevant and the other was variable-irrelevant. The rewarded component of the relevant dimension was designated at random and this component was paired with each component of the irrelevant dimension an equal number of times on the right and left. A marble served as the reward stimulus. Correct responses also were rewarded with "good" and incorrect responses were punished with "no." Correction of erroneous responses was not allowed. Position of reward was determined by a Gellermann series.

Problem 2 of the RV shift involved the same stimuli as Problem 1. However, a response to the previously negative component now was rewarded. In Problem 2 of the ID and ED shifts, two new values on both the color and form dimensions were introduced. The relevant and irrelevant dimensions were unchanged in the ID shift, while in the ED shift the relevant Problem 1 dimension became irrelevant and vice-versa. Color was relevant in Problem 2 for half the Ss in each shift group, and form was relevant for the remaining Ss.

The Ss were 48 children attending the Institute of Child Behavior and Development Preschool Laboratories and the Iowa City Parents' Cooperative Preschool. Ss were assigned at random to the six shift-by-dimension groups (8 Ss/group). CAs ranged from 45 to 67 mos. with a mean of 56.1 mos.

Three experimental sessions were required for each S. These sessions generally were separated by a period of two days. On the first day, pretraining was given on a discrimination involving a pair of "junk" stimuli. Pretraining was continued until a criterion of 10 consecutive correct responses was reached. On the second day, each S again was brought to a criterion of 10 consecutive correct responses on the pretraining problem. Immediately after reaching criterion, the S began training on Problem 1 and continued until a criterion of 10 consecutive correct responses was reached. If S had not attained this criterion at the end of 40 trials, a special training procedure was instituted to assure learning. Without mentioning the color or form of the stimuli, the E showed the two positive stimulus objects to the S and said, "These blocks are right. The marble is always in these blocks."

The E then presented the two negative stimulus objects and said, "These blocks are wrong. The marble is never in these blocks." Following this special training, all Ss began criterion performance within 15 trials. On the final day, each S relearned Problem 1 to a criterion of 10 consecutive correct responses. Then training was begun immediately on Problem 2 and continued until a criterion of 20 consecutive correct responses was reached, or for a total of 80 trials.

Results

Means of the error scores for the three shift groups are given in Table 1. Each error score was either the number or errors to criterion or the number of errors to the end of training (80 trials).

Since the subgroup variances were extremely heterogeneous, an extension of the analysis of variance by ranks was used. A 3 by 2 factorial analysis of variance of this type was performed on the error scores. In this analysis, the factors were type of shift and relevant dimension in Problem 2. The Type-of-Shift main effect was significant, $H=14.53$, $df=2$, $p<.001$. The Relevant-Dimension main effect was not significant, $H=0.71$, $df=1$, $p>.30$. In addition, the interaction of these two factors was nonsignificant, $H=1.13$, $df=2$, $p>.50$. In order to determine the source of the significant Type-of-Shift main effect, three Mann-Whitney U tests were performed. The results of these tests indicated that, while the RV and ID shifts did not differ significantly in difficulty, both were significantly less difficult than the ED shift ($p<.002$ for both tests).

Table 1. Means of Error Scores for the Three Shift Groups

Shift	Form	Color	Total
RV	1.38	1.25	1.32
ID	1.00	5.25	3.12
ED	10.25	22.38	15.50

Discussion

The results of this experiment strongly suggest that preschool children make mediational responses to the relevant dimension of discrimination problems, and that they transfer these responses to subsequent problems. In addition, Shepp & Eimas (1964) have reported data showing that even rats learn ID shifts faster than ED shifts. Thus, it appears unnecessary to assume a developmental change in the discrimination learning process in order to explain the disparate findings. Other experiments with young children may have employed ED-shift procedures which have served to minimize the interfering effects of mediating responses.

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Notes

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2. Now at the University of Connecticut.

Verbal paired-associate transfer as a function of practice and paradigm shift

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Two studies investigated the effects of practice and paradigm shift on three transfer paradigms: A-B', A-B; A-C, A-B; and C-D, A-B. Ss were administered the same paradigm for three successive sets of paired associates after which they were either continued with the same paradigm for a fourth set or shifted to a different paradigm. Performance under the A-B' paradigm tended to diverge from the other paradigms as a function of sets. Paradigm shift did not affect performance beyond that expected on the basis of the nature of the paradigm shifted to.

In studying the relationship between practice and transfer variables in verbal paired-associate learning, Postman (1964) recently compared a positive transfer paradigm involving synonymous responses (A-B', A-B) and two negative transfer paradigms involving unrelated and repaired responses (A-C, A-B; A-B, A-Br) with a reference condition of unrelated stimuli and responses (C-D, A-B). Each of the four groups learned three sets of two paired-associate lists. Relative to the reference condition, there was a progressive increase in positive transfer over successive sets under the A-B' paradigm and a decrease in negative transfer under the A-C and A-Br paradigms.

The increase in positive transfer in the A-B' paradigm was assumed to have occurred as a consequence of increased use of mediational chaining. It was also suggested that the reduction in negative transfer in the A-C paradigm may have reflected the development of a strategy of rejecting old associations and/or the development of mediational chaining strategies even though the responses were unrelated. Assuming the latter, progressive increases in transfer under the A-B' and A-C paradigms would reflect differences in the nature of the mediational chains rather than the development of different strategies.

In the present study, the effects of practice with A-B', A-C and C-D paradigms were studied for three sets of paired associates after which Ss were either continued with the same paradigm for a fourth set or shifted to a different paradigm. On the assumption that the development of a general mediational strategy underlies performance changes in both the A-B' and A-C conditions, it would be expected that performance under A-C test conditions would be better following A-B' training than following C-D training and that performance under an A-B' paradigm would be better following A-C training than following C-D training.

EXPERIMENT 1

Method

Three paradigms were used in the present experiment: A-B', A-B (mediation); A-C, A-B (interference); and

C-D, A-B (learning to learn). For any given S the paradigm was the same for the first three sets; on the fourth set S was shifted to another paradigm or continued with the same paradigm depending on the group to which he was assigned. The experiment was essentially a 3 by 3 factorial with one variable representing type of paradigm over the first three sets (training) and the other variable representing type of paradigm on the fourth set (test).

The design, procedure and materials were essentially the same as those employed by Postman with the exception that in the present experiment Ss learned four rather than three sets. The four sets were administered in four different sequences equally often. The B'-B pairs were 32 synonyms; 17 were selected from Haagen's list (1949) with a mean similarity rating of 1.3, 13 were selected from Melton and Safir's lists (Hilgard, 1951) with a mean rating of 2.6 and two additional pairs were constructed which did not appear in either of these lists.

The materials were made into slides and presented by means of a Carousel projector. Four different random orders of each list were constructed and were presented at a 2:2 sec. rate with an 8 sec. intertrial interval. The first list of each set was learned to a criterion of 7/8 and the second list was presented for five successive trials. With three training paradigms, three test paradigms, four sequences and two experimenters, there were a total of 72 groups, three Ss being assigned at random to each group. A total of 216 female Ss from Introductory Psychology classes served in the experiment.

Results and Discussion

An analysis of variance on the number of trials to criterion on the first lists of each set yielded a significant main effect of Sets, $F = 334.31$, $df = 3/432$, $p < .001$. The means were 12.18, 5.79, 5.31, and 5.23 for Sets 1-4 respectively. In agreement with Postman's results there was a reduction in trials to criterion as a function of sets, the greatest reduction occurring from the first to the second set. However, all possible interactions among Sets, Training paradigms, and Sequence were significant (all p 's $< .05$) reflecting inconsistent trends among the second, third and fourth sets in some groups. There was also a significant main effect of Experimenter ($p < .05$).

Figure 1 presents the mean number of correct responses on the second lists as a function of sets for the different training and test paradigms. An analysis of variance on these data indicated that all main effects and interactions among Training paradigms,

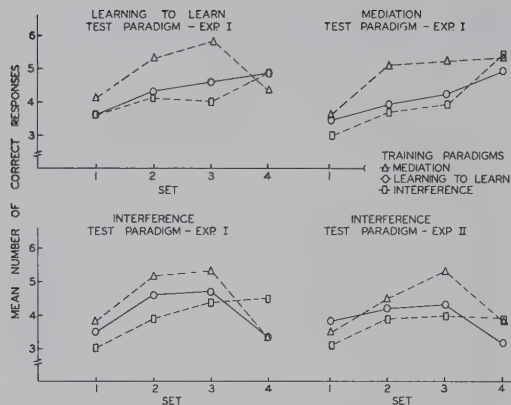


Fig. 1. Mean number of correct responses per trial on second lists as a function of sets and paradigms.

Test paradigms, and Sets were highly significant ($p < .001$), with the exception of the Training paradigm by Test Paradigm by Sets interaction which approached significance $F=1.66$, $df=12/432$, $.10 > p > .05$. Since for any given group the paradigm was constant over the first three sets the finding that performance under the A-B' paradigm tends to diverge from the other paradigms over these three sets may be considered a replication of the Postman experiment.

The question of primary interest is whether test paradigm performance is dependent upon the nature of previous training experience. Therefore, an analysis of variance was conducted on the fourth set. The main effects of Training paradigms, $F=3.92$, $df=2/144$, $p < .02$, and Test paradigms, $F=19.46$, $df=2/144$, $p < .001$, were the only significant sources of variance. The latter effect indicates that, consistent with previous research in paired associate learning, the nature of the learning paradigm differentially affects performance, i.e., relative to the C-D reference paradigm the A-B' paradigm produces positive transfer and the A-C paradigm produces negative transfer. The mean number of correct responses per trial on the fourth set were 5.22, 4.65 and 3.68 for the A-B', C-D and A-C test paradigms respectively.

The significant main effect for Training paradigms also indicates that regardless of the test paradigm, training under the A-C paradigm results in better performance on the fourth set ($M=4.92$) than does training under either the A-B' ($M=4.31$) or C-D paradigms ($M=4.32$). Since this finding was somewhat unexpected particularly in the absence of obtaining similar effects for Ss receiving the A-B' paradigm in training, a second experiment was conducted to determine its reliability. Inasmuch as Fig. 1 suggests that the

superiority of A-C training was most pronounced under A-C test conditions, only A-C test conditions were employed in the second experiment.

EXPERIMENT 2

Method

The same procedure was used as in the first experiment. There were three main groups representing three training paradigms on the first three sets: A-B', A-C, and C-D. On the fourth set all groups received the A-C paradigm. Four sequences and two experimenters yielded a total of 24 groups, with three female Ss per group.

Results and Discussion

The mean number of trials to criterion on the first lists were 12.06, 6.42, 5.93, and 5.58 for Sets 1-4 respectively. The only effect to reach statistical significance was Sets, $F=82.79$, $df=3/144$, $p < .001$.

Figure 1 presents the mean number of correct responses on the second lists as a function of Sets for the three groups. There were significant ($p < .001$) main effects of Trials and Sets, and significant interactions of Training Paradigms by Sets, $F=7.12$, $df=6/144$, $p < .001$, and of Paradigms by Sets by Trials, $F=1.61$, $df=24/576$, $p < .05$. As in the first experiment, the divergence over the first three sets of the A-B' from the other two paradigms is apparent.

An analysis of variance on the fourth set failed to yield a significant main effect of Training $F=1.43$, $df=2/48$, or a significant Training by Trial interaction, $F < 1$. Thus these results do not support the finding in Experiment 1 of the superiority of A-C training for A-C test conditions. However, it should be noted that for groups receiving the A-B' and C-D training paradigms the decrement in performance under the A-C test paradigm was obtained in both experiments.

The results of Experiments 1 and 2 suggest that, within the limits of the number of training sets employed, test performance is primarily a function of the nature of the test paradigm and does not interact with conditions of training. Thus there is no evidence to support the hypothesis that relative to training under C-D conditions, the development of general mediational chaining strategies under A-B' and A-C training paradigms will facilitate performance under the alternate A-C and A-B' test paradigms.

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A shift from "negative" to "positive" transfer under the A-C paradigm with increased number of C-D control pairs in a mixed list¹

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Transfer under a standard A-C (first-list stimuli paired with new responses) verbal paired-associate transfer paradigm was found to shift from positive when only two A-C pairs were included with six new C-D control pairs in a mixed list, to increasing negative transfer with four pairs of both types, and with six A-C along with two C-D pairs. Since the latter most closely corresponds to typical mixed-list transfer conditions, these results are indicative of a spurious overestimate of negative transfer for other paradigms under mixed-list conditions.

Amidst the host of inconsistencies pervading the literature on intertask similarity effects upon transfer (see, e.g., Battig, 1966; Underwood, 1961), there has been widespread agreement and acceptance of (a) new responses paired with old first-list stimuli (A-C paradigm) as a condition producing consistent and significant negative transfer, and (b) the equivalence of the transfer effects produced by the A-C and other transfer paradigms under mixed- and unmixed-list procedures (Twedt & Underwood, 1959). Mixed-list transfer comparisons, however, have almost without exception included more than one transfer condition or paradigm in addition to the C-D control paradigm (e.g., Kausler & Kanoti, 1963; Mandler & Heinemann, 1956; Merikle & Battig, 1963; Twedt & Underwood, 1959), so that the second transfer list has contained fewer new C-D control pairs than pairs containing one or more first-list items. That such conditions may produce spurious negative transfer is suggested by Battig & Berry's (in press) recent demonstration of a marked facilitation on new C-D pairs (relative to pairs consisting of individual items previously used in a verbal-discrimination or multiple-choice recognition task) when there were fewer new than pretrained pairs in the PA list. This "negative" transfer on pretrained pairs contrasted sharply with the generally positive effects of pretraining when the number of pretrained pairs was equal to or fewer than the number of new pairs. These differential transfer effects were interpreted as reflecting a kind of "isolation" effect, such that "S's attention is attracted to pairs consisting of new previously unseen items when there are relatively few of these" (Battig & Berry, in press).

The purpose of the present study was to determine whether variations in the proportion of new C-D pairs in a mixed list may produce similar differential transfer effects under the standard A-C transfer

paradigm. Selection of the A-C paradigm for this comparison was based upon the predominant interest in this paradigm in previous transfer research, along with its apparent greater stability than other transfer paradigms under systematic variations in such other factors as meaningfulness (e.g., Merikle & Battig, 1963).

Method

Each of 36 Ss learned in succession two eight-pair CVC lists, using the recall method with a 4-sec. presentation rate and a 12-sec. intertrial interval. All Ss learned the first list to a criterion of 40 total correct responses summed over all trials, whereas second-list learning was to a criterion of two successive errorless trials.

Three groups of 12 Ss each differed solely as to number of the eight second-list pairs representing A-C and new C-D pairs. Under the 2-6 condition, there were two A-C and six C-D pairs. The 4-4 condition involved equal numbers (four) of A-C and C-D pairs, whereas the 6-2 condition consisted of six A-C and two C-D pairs. All groups learned the same second list of eight moderate association-value CVC pairs previously shown to be equivalent in rated learning difficulty (Battig, 1960), and of minimal intralist similarity. To counterbalance individual second-list pairs with respect to their representation of A-C and C-D paradigms, four different first lists were used under 2-6 and 6-2 conditions, with two first lists under the 4-4 condition. Each A-C first-list pair was constructed by pairing the second-list stimulus term with a new response CVC of equivalent association value. All remaining first-list pairs were comparable to the second-list pairs in rated learning difficulty (Battig, 1960) but consisted of two CVCs maximally dissimilar to any appearing in the second list.

Each of three Es ran one-third of the Ss under each condition, with an equal number of Ss using each first list within each condition. Assignment of Ss to Es and conditions was unsystematic, based upon a combination of coincidence of free times for Ss and Es with a predetermined different order for each E specifying assignment of Ss to lists and conditions.

Results

Total errors to criterion on the first list proved to be closely comparable across the three groups ($F < 1$), and also did not differ significantly between the three Es and the various lists within conditions. Although more total second-list errors were made under the 2-6

condition (37.5) than the 4-4 or 6-2 conditions (both 31.2), this difference also fell far short of significance ($F < 1$).

Relative performance on A-C and C-D pairs, however, did differ systematically across the three conditions. Under the 2-6 condition, fewer mean errors per pair were made on A-C (4.38) than C-D pairs (4.97), and nine of the 12 Ss showed superior performance on A-C pairs. Although absolute performance on the A-C pairs actually improved slightly with increasing numbers of these under both 4-4 (4.11) and 6-2 (4.10) conditions, C-D performance showed a far greater progressive improvement under 4-4 (3.77) and 6-2 (3.25) conditions. Within each of the latter two groups, eight of the 12 Ss made more errors per pair on A-C than on C-D pairs. The indicated improvement on C-D pairs with decreasing numbers thereof fell short of significance ($p < .10$), however, even by analysis of covariance based on first-list total errors as a covariate. Likewise, the improvement on C-D relative to A-C pairs from 2-6 to 6-2 conditions did not attain statistical significance ($p = .10$).

Closer examination of the data for individual Ss indicated the nonsignificance of the differences between conditions to be attributable to a general tendency for those few Ss showing negative A-C transfer in the 2-6 group, and positive A-C transfer in the 4-4 and 6-2 groups, to have made significantly more ($p < .025$) total second-list errors (44.8) than did the remaining Ss (28.9). To eliminate the excessive weighting in the previous analyses of the transfer performance of these few deviant Ss, a percentage transfer measure was calculated for each S by dividing the difference between C-D and A-C mean errors per pair by the sum of these two values (Murdock, 1957; Formula 3b). This measure showed a highly significant ($p = .005$) decrease from the 2-6 (12.5%) to 4-4 (-14.5%) and 6-2 conditions (-20.3%).

Discussion

In agreement with the findings of Battig & Berry (in press), the present results clearly show a significant improvement in relative performance on C-D pairs as the number of these included in an eight-pair list decreases from six to two. Thus if new C-D pairs represent the transfer baseline under mixed-list conditions, transfer under the A-C paradigm changes from positive when the list consists predominantly of C-D pairs to negative when the latter pairs are equivalent or fewer in number as compared with A-C pairs. Since previous mixed-list transfer comparisons have typically included a minority of C-D pairs, it is apparent that amount of negative transfer under other paradigms has

been spuriously overestimated as a result of the facilitation of performance on the small number of C-D pairs employed in these mixed-list comparisons.

Further support for the Battig-Berry (in press) interpretation of the facilitation on a minority of C-D pairs as representing a kind of "isolation" effect is provided by the present finding that those few Ss who failed to show facilitated performance on whichever type of pair was in the minority also showed a significant decrement in overall second-list performance as compared with the other Ss. This result further suggests that classification of second-list pairs into two or more types or categories offers an important means whereby Ss can combat interference in paired-associate learning, particularly for a type of pair representing a minority of the list. Thus besides pointing to a possible source of contamination in mixed-list transfer comparisons, the present results suggest the mixed-list procedure to offer a potentially useful technique for the systematic manipulation of sources of inter- and intralist interference and the investigation of techniques employed by Ss to overcome such interference (Postman, 1963).

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Note

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Paired-associate learning: Similarity among stimulus terms¹

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A paired-associate verbal learning experiment was conducted and replicated. Intralist similarity of stimulus elements was varied and the position of these similar elements was varied. The stimulus terms (CVC trigrams) had either one or two elements in common and occurred in either the initial or final position of the trigram. The experimental design involved three variables: number of elements in common among the stimulus terms (1 vs. 2); position of common elements (Final vs. Initial); and, replication (1 vs. II). An analysis of the results revealed no significant interaction of any of the variables and no significant main effects of replication or position of common elements (.05 level). A significant main effect of number of shared elements was found. When the stimulus terms of a paired-associates task have two letters in common, then the task is more difficult than when there is only one element in common. This finding was pronounced in both replications involving different letters.

Intralist similarity has been shown to have an effect on verbal learning (Underwood & Postman, 1962). In a paired-associate task, intralist similarity can be manipulated within the stimulus terms, the response terms, or both. Furthermore, similarity can be viewed from several different definitions. The terms can be synonyms, homonyms, or the terms can have varying elements (letters) in common (Newman & Taylor, 1963). Newman & Taylor (1963) found that a group of college students performed less well on a High Sharing list (all stimulus terms constructed from only four consonants) than did a group who had a Low Sharing list (all stimulus terms constructed from 10 consonants).

In the present experiment, consonant-vowel-consonant trigrams (CVC) were used as stimulus terms and single digits as response terms. The number of shared elements among the stimulus terms and the position of these shared elements were both varied. In addition, the experiment was replicated using different CVC trigrams.

Method

The entire population of a residential institution was given the Peabody Picture Vocabulary Test. A pool of 128 Ss was formed by taking all Ss who had scored between IQ 63 and 85, inclusive, on this test. From this pool of Ss, eight random samples of 12 Ss each were selected. Replacements, when necessary, were randomly drawn from the remaining pool of 32 Ss. Prior to the experiment all Ss were shown the numbers to be used as response terms and asked to identify them. If, after 10 trials of practice with the numbers, the S could not identify them without errors on two successive

trials, he was dropped from the experiment. Thus, any S who participated in the experiment could identify the numbers without error. An analysis of variance revealed no significant differences among the groups in terms of CA, MA, and IQ.

The paired-associate lists were typed on punched tape and presented with a Lafayette Memory Drum, Model 303B.

The experimental design was a 2 by 2 by 2 factorial; the number of common elements among the stimulus terms was varied (1 vs. 2), the position of the common elements was varied (beginning of word vs. end of word, or Initial vs. Final), and the experiment was replicated with different letters (Replication 1 vs. Replication 2). The Ss were assigned randomly to the eight independent groups. The ordering of the paired-associate lists in Table 1 portrays the experimental design. Columns 1 and 2 are Replication 1 and Columns 3 and 4 are Replication 2. Columns 1 and 3 have one common element among the stimulus terms and Columns 2 and 4 have two common elements among the stimulus terms. Row 1 represents the common element(s) as being at the beginning of the word (Initial) and Row 2 represents the common element(s) as being in the final position in the word (Final).³

In setting up the paired-associate lists the words in List A were paired randomly with the numbers 4, 5, 9, 2, and 1. For the other lists the same consonants received the same number pairing. For example, POD was paired randomly with 4 in List A; hence, in list B, PAD was paired with number 4. The pairings for Replication 2 were made in the same manner but with the numbers 3, 4, 5, 6, 8. To avoid or minimize serial

Table 1.
The Experimental Design and the Eight Lists of Paired-Associates

	Replication 1		Replication 2	
	1 Letter	2 Letters	1 Letter	2 Letters
	List A	List B	List E	List F
Initial	PEN 9	PAN 9	MIC 3	MEC 3
	PAT 2	PAT 2	MOT 8	MET 8
	PIL 1	PAL 1	MUL 5	MEL 5
	POD 4	PAD 4	MAB 4	MEB 4
	PUC 5	PAC 5	MED 6	MED 6
	List C	List D	List G	List H
Final	TOP 2	TAP 2	DEM 6	DEM 6
	LAP 1	LAP 1	CIM 3	CEM 3
	NIP 9	NAP 9	BOM 4	BEM 4
	DEP 4	DAP 4	TAM 8	TEM 8
	CUP 5	CAP 5	LAM 5	LEM 5

effects, eight different random orders of the items within a list were constituted. The order of these random lists was determined from a table of random numbers and the lists were presented to every S in the same order. If more than eight trials were required to reach criterion, then the order of the lists was repeated.

Each S was escorted into the experimental room and told that he could earn the money on the table (3 cents) if he did well on the task. The task was first demonstrated with a folded index card, S being required to look at the CVCs and say the numbers when they were exposed. Then the task was presented on the memory drum for the remainder of the experiment. Early in the session the S was encouraged to guess the number before it appeared in the aperture and occasionally told that he was doing a good job and would win the money if he kept doing well.

The stimulus terms were each exposed for 4 sec. and then the shutter exposed the response term with the stimulus term for 4 sec. The drum then required approximately 1 sec. to move to the next stimulus term. The intertrial interval was approximately 8 sec.

A learning criterion of two consecutive correct trials through the list (five paired-associates) was established prior to the experiment. An arbitrary limit of 75 trials was imposed. If a S did not have two consecutive correct trials by the 75th trial, then the session was terminated and the S given a score of 75.

Results and Discussion

The means and SDs of the trials to criterion (two successive correct trials) for the various groups are given in Table 2. The number of children within each group who were terminated and given a score of 75 when they reached the arbitrary upper limit of 75 trials is given in Table 3.

An analysis of variance (2 by 2 by 2) was applied to the data summarized in Table 2. None of the interactions were significant at the .05 level and there was no evidence for a difference attributable to replication or position of shared elements (Initial vs. Final). The effect of number of shared elements was significant

Table 2. Trials to Criterion for the Various Subgroups

		Replication 1	
		One Letter	Two Letters
Initial	Mean	39.33	54.08
	SD	23.97	25.91
Final	Mean	32.17	43.08
	SD	15.42	26.53
		Replication 2	
Initial	Mean	32.08	52.08
	SD	21.01	24.50
Final	Mean	29.33	45.58
	SD	19.17	26.14

Table 3.

Number of Subjects Who Reached the Upper Limit of 75 Trials

	Replication 1	
	One Letter	Two Letters
Initial Position	3	7
Final Position	0	4
	Replication 2	
	One Letter	Two Letters
Initial Position	2	6
Final Position	1	4

at the .01 level ($F=9.05$, $df=1/88$) with significantly more trials required to learn the lists in which the stimulus terms shared two elements in common. This finding is consistent with previous experimentation using both serial and paired-associates verbal tasks.

Within a language training session involving a paired-associate task (e.g., vocal responses to printed words), what groupings of elements among words will facilitate learning and what groupings will retard correct performance? From the results of the present study it appears that such learning can be retarded when there is a great deal of commonality of elements among the stimulus terms, i.e., the printed words. The results suggest that the proficiency of language can be improved by using classroom programs which are relatively free of intralist similarity among the stimulus terms. These results, however, apply to a single learning session and additional experimentation is needed to determine how such learning progresses over several sessions.

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Notes

- This study was supported by Grant HD 00870-01 from the National Institute of Child Health and Human Development to the Bureau of Child Research, University of Kansas.
- Now Field Director, Bureau of Child Research Laboratory, Children's Rehabilitation Unit, University of Kansas Medical Center, Kansas City, Kansas.
- In List G of Table 1 the last stimulus term should have been LUM instead of LAM. This error, which occurred on the original memory drum tape, was discovered after the study was completed. It can be contended that the error is not too serious if one compares the means found in Table 2. The mean trials to criterion for this group was 29.33, whereas, for the corresponding group in Replication 1, the mean is 32.17. Had the effect of the error been pronounced one would expect the group in which the error occurred to have taken more trials than the corresponding group in Replication 1. In addition, the difference between the means of the Final-One Letter group and the Final-Two Letters group of Replication 1 is about the same as the corresponding difference in Replication 2.

Frustration effects rather than Sr effects in children

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A light was paired with token rewards for experimental children, and was unpaired for control children. Extinction of a cranking response was accompanied by periodic presentation of the light. Contrary to Sr predictions, experimental Ss extinguished first. A frustration interpretation seems more appropriate.

Although several studies with human Ss have led their authors to the conclusion that secondary reinforcement effects (Sr effects) were demonstrated (see Myers & Myers, 1965, for some of these references), another list may be mentioned which led its authors to the conclusion that Sr effects were not demonstrated (e.g., Kass et al, 1964; Longstreth, 1960; Mitrano, 1939). Normally an investigator mentions one list or the other, but not both (unless the editor insists upon it), depending upon how his own results turned out. There is a third list, however, which is seldom mentioned in either type of study, even though the independent variable involves the same basic operation as employed in Sr studies. Reference is made here to a growing list of frustration studies with human Ss (e.g., Haner & Brown, 1955; Holton, 1961; Longstreth, 1965). In both Sr and frustration studies, the experimental condition involves pairing a cue with reward and then presenting it alone, while control conditions hold exposure to the stimuli constant, but omit the pairing. If the experimental condition leads to greater resistance to extinction, it is usually concluded that Sr effects were demonstrated; if the control conditions lead to greater resistance to extinction, it is often concluded that frustration effects were demonstrated.

Now clearly, both results cannot be presumed to follow from the same operation, since they are mutually contradictory. Perhaps, then, some of the results would not withstand a replication. Or it could be that subtle factors were operating which are usually overlooked in the typical published report. Of these two possibilities, the first has priority: there is little sense in looking for subtle factors which produce unreliable results. Thus a first step in understanding these apparently contradictory results is to make sure the difference is *real*, not just apparent. The present paper reports a study which parallels closely the procedures in a previous study which did not find Sr effects, but rather frustration effects (Longstreth, 1960).

Method

Ss were 40 kindergarten children from a public school who were randomly assigned to an experimental and control group, with the restriction that $N=20$ per group.

The apparatus consisted of two main units, a crank token-reward machine and E's control box. The crank

machine was a wooden black box 23 in. high, 14 in. wide, and 6 in. deep, with a crank handle mounted on one side. An ejection slot, cut in the front face, delivered tokens (poker chips) as controlled by E. A blue 120-volt light bulb, also controlled by E, projected from the top of the crank machine at approximately S's eyelevel.

The control unit consisted basically of two selector switches and an impulse counter. One switch allowed E to select which turn of the crank handle would lead to ejection of a token, while the second switch determined which turn of the crank would momentarily activate the blue light. The counter automatically counted the number of turns made by each S.

Training consisted of cranking until 14 tokens were earned. Each token was placed in a slot on a 15-slot board, at the end of which was a prize S had selected. The number of cranks per token varied from 3 to 15 in units of 3, with a median of 8. The sequence was 6, 9, 3, 12, 6, 15, 9, 6, 6, 12, 15, 3, 12, 6. Thus all Ss cranked a total of 120 times prior to extinction.

Pairing of the blue light with token ejection constituted the independent variable. For experimental Ss, the light was automatically activated one crank prior to token ejection and terminated simultaneously one crank later. For control Ss the light was activated on the crank corresponding to one-third the number required for a token on that trial. Thus, if 9 cranks were required, the light was activated on the third crank and terminated on the fourth. The crucial difference between groups was that the light was paired with token ejection for experimental Ss but not for control Ss.

Extinction began with no interruption: the fifteenth token was simply not delivered. For both groups the light was automatically activated every ninth crank and terminated one crank later. The extinction criteria were either a cessation of cranking for more than 1 sec. or the third cessation of less than a second's duration. When one of these criteria was reached, the fifteenth token was ejected, S collected his prize, and was returned to his room.

During both training and extinction, E sat behind a curtain which shielded him from S's vision. Children seem to be quite sensitive to subtle cues from E regarding whether they should continue responding or stop, necessitating some such precaution.

Results

Table 1 presents the raw data: the number of cranks to extinction by each S. The mean for experimental Ss is 33.2, and for control Ss, 74.7. Both a t-test and a Chi Square test indicated this difference is significant at $p < .01$. It is clear that experimental Ss extinguished faster than control Ss.

Table 1. Number of responses to extinction

Subjects	Experimental Group		Control Group	
1 11	9	21	43	120
2 12	13	45	57	19
3 13	46	12	72	147
4 14	48	21	133	106
5 15	14	35	43	54
6 16	21	26	190	49
7 17	16	18	64	39
8 18	150	9	32	75
9 19	89	10	65	40
10 20	23	37	102	44

Any verbal responses during extinction that expressed the correct relationship between the light and token ejection were recorded. For instance, if S said, "The light turns on, but the chip doesn't come out," a note was entered on S's data sheet indicating the response. Of the 11 Ss who made such responses, 9 were in the experimental group, and 10 extinguished with fewer than the overall median number of cranks to extinction. Both of these relationships were significant as evaluated by Chi Square ($p < .05$).

Discussion

The present results closely parallel those of a previous study (Longstreth, 1960). In both studies, the experimental group was exposed to the pairing of a light with reward, while the control group was not. In extinction, the light was presented to both groups, but not the reward. In both studies, (a) experimental Ss verbalized their expectation of reward when the light was presented, and (b) extinguished faster. How are these results to be rationalized?

According to the notion of secondary reinforcement, the light should have become an Sr for experimental Ss, and hence should have strengthened preceding responses. Thus experimental Ss should have extinguished slower. Clearly, Sr predictions are not supported.

Turning to frustration theory, it would be assumed that the light would elicit anticipations of a token in experimental Ss, as was confirmed by verbal responses.

Such nonreinforced anticipations in extinction would lead to maximum frustration, which would produce aversive emotional responses. Such aversiveness could be reduced by avoiding the situation, and hence should lead to rapid extinction. Frustration theory, then, is strongly supported by the data.

It would appear that frustration effects can be reliably produced with human Ss. But presumably, so can Sr effects. What is the key to the difference? One possibility is that some studies which have been interpreted as supporting Sr predictions can be re-interpreted as supporting frustration theory. This would appear to be a particularly appropriate possibility for those studies which measure only a small part of extinction and find stronger or more rapid responses for Ss exposed to assumed secondary reinforcers. According to frustration theory, such results may be nothing more than a frustration effect. An additional prediction, of course, would be that such Ss would extinguish faster. Unfortunately, most studies reporting Sr effects have not measured resistance to extinction. Until more complete information is available, the present state of confusion is likely to continue.

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Note

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Practice and compatibility in 2-channel short-term memory

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Eleven Ss were required to listen to three pairs of digits presented dichotically. The member of each pair arrived simultaneously at opposite ears. They were asked to recall them either vocally, alternating between the ears, or manually on a keyboard which allowed them to respond to both ears at once. Contrary to Broadbent's earlier findings, very high levels of recall can be achieved in both conditions when the presentation rate is as high as 2 signals/ear/second.

Broadbent (1954) presented a S with a dichotic memory span task in which three pairs of digits were presented to a listener, one item of each pair being presented to S's right ear at the same moment that the other was presented to his left ear. If the three pairs of digits arrived at a rate greater than about one pair/1-1/2 sec., S could only recall them correctly if they were recalled ear by ear (LLRRR, hereafter called "Successive"), but not if they were recalled alternately from each ear (LRLRLR, called by Broadbent "in the correct order of arrival," and which we will call "Alternating").

Moray (1960) queried Broadbent's conclusions about the time it takes to switch attention from one channel to another, and also the necessity for postulating a short-term memory store near the input end of the system to account for the success of the recall strategy called "Successive." Moreover, recently there have been several pieces of research which strongly suggest that retrieval is a very important part of transmission of information, and that the input/output compatibility is crucial for successful retrieval. (Sperling, 1960; Moray & Barnett, 1965; Moray, Bates, & Barnett, 1965; Fitts & Seegar, 1954; Leonard, 1959). Also that practice can make a very big difference in performance in high-load transmission tasks (Mowbray & Rhoades, 1959; Davis, Moray, & Treisman, 1961).

One feature of Broadbent's (1954) experiment stands out: it was impossible in his experiments for S to respond to the signals "in the actual order of arrival," for this would have necessitated them either saying or writing two digits at once. The experimental situation was one which demanded the serializing of a parallel input in order for responses to be made. Retrieval was therefore difficult.

The following experiment was designed to investigate the role of practice and compatibility in dichotic memory span tasks under optimal retrieval conditions.

Method and Procedure

Ss listened to lists of three pairs of digits chosen from the numbers 0-9. In each set of three pairs no digit was

repeated. Otherwise the lists were chosen randomly. The pairs were presented over headphones arranged for dichotic presentation. The left ear received one member of each pair at the same time that the right ear received the other. Simultaneity was checked and any non-synchronous pairs re-recorded. The lists were presented at two pairs per second (=2 signals/ear/second). A Brennell Mk. V tape recorder and Brown Type K 50 ohm headphones were used to present the stimuli. S received one list of three pairs every 15 sec. During the following 15 sec. S had to record his response.

Ss were required to recall either by speaking, alternating from ear to ear (LRLRLR response), called hereafter the Vocal Alternating condition, in which case the experimenter wrote down their responses; or by means of a keyboard which allowed them to press two keys simultaneously, one with the right hand (for the right-ear message) and one with the left hand (for the left ear message), called hereafter the Manual Simultaneous condition. The keyboard was that of a "Palantype" machine, which is a European version of the "Stenotype" machine, normally used for highspeed dictation. Essentially it consists of a typewriter in which the keys are arranged to match the positions of the fingers, and in which if two keys are pressed simultaneously two figures are printed side by side. Keys were allocated to the numbers 0-9 for each hand. The S was not allowed to see the output tape from the Palantype.

Ss were 11 students and research workers of the Sheffield University Department of Psychology, aged between 18 and 35.

Ss attended two sessions, one for practice and one for experimental purposes.

In the Practice session they received 25 lists with Manual Simultaneous output, 25 with Vocal Alternating, 25 with Vocal Alternating and 25 with Manual Simultaneous. There was a short rest period between each group of 25 lists. In the experimental session the order was 25 Vocal, 25 Manual, 25 Vocal, 25 Manual.

Results

Because of the high inter-S variability the results of each S for 50 lists are presented individually in Table 1.

Discussion

Firstly, the two handed output condition allows very high scores to be obtained. Once scores are over 90% we are in the same range that is seen in the LLLRRR condition in the earlier experiments, and are indeed so

Table 1. Percentage totally correct lists based on fifty lists per subject in each response condition

Subject	Response Condition	
	Manual Simultaneous	Vocal Alternating
1	88	74
2	92	92
3	66	42
4	36	42
5	64	26
6	62	40
7	88	68
8	84	88
9	90	82
10	50	28
11	66	68
Mean %	71.5	59.1
Mean (Raw Scores)	35.72/50	29.54/50
s.d. (Raw Scores)	8.81	11.53

near to perfect recall that the shortfall can easily be accounted for on the basis of acoustic confusion between signals and the lack of experience in making the motor responses required. Secondly, even when giving the Vocal Alternating responses, Ss are performing at a much higher level than in any previous experiments. Broadbent (1954) and Moray & Barnett (1965) both found only about 20% correct in the Alternating recall condition at 2/ear/second presentation.

The first conclusion that we may draw from the data is that yet again the very great importance of compatible input-output relationships has been demonstrated with respect to the optimizing of information transmission. There remains the difficulty in accounting for the enormous discrepancy in the Vocal Alternating condition between this study and earlier ones.

A close examination of Broadbent's original procedure reveals that in his 3-pairs-per-list condition half his Ss received only 10 lists in all, and the other half 24 lists in all in which they could give the Vocal Alternating response to a simultaneous dichotic input. Similarly Moray and Barnett's Ss received only 20 lists in which they were explicitly asked to recall with Vocal Alternating responses, of which half were at 2 pairs/second and half at 1 pair/second. Clearly neither of the previous studies even begins satisfactorily to explore the performance levels to which practice might give rise.

In the present study Ss received 50 practice lists under the Manual Simultaneous response condition and 50 practice lists under the Vocal Alternating response condition. They then received a further 50 of each in the experimental session. In the practice sessions the total correct for each response condition is only (on the average) 13% lower than the experimental condition

which gives levels of performance about twice those previously found.

The role of practice is underlined by the fact that in a more recent experiment a S who in his first run of 20 Manual Simultaneous responses only reached 30% correct reached 80% in the next run. After very little practice there is little or no difference between any of the conditions, although our impression is that the LRLRLR condition, whether manual or vocal, is probably subjectively the hardest of all. In a control experiment using the same Ss the Manual Successive (LLLRRR) condition gave the same performance as all previous experiments using Vocal Successive have found, namely an average of 90% correct at least.

The interpretation of Broadbent's (1954) experiment thus becomes that with 2-channel input of messages consisting of pairs of digits some part of the system is overloaded if there is only a single output channel if the messages arrive at more than about 6.64 bits/second (=1 pair per second), in unpractised Ss. He rightly interpreted the effect as relating to the funnelling effect of 2-channel input into single channel output, i.e., in some way relating to the processing of parallel messages into a serial form.

The present study shows (a) that with practice this recoding becomes much more fluent, and (b) that if parallel-to-serial processing is not needed, but merely the labelling of messages as to which input/output line they are using, and if compatible output lines are provided, then no such parallel to serial recoding is required, and the signal transmission rate can be very greatly increased.

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Sex, stimulus, association strength, duration and rate of repetition in semantic satiation¹

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Forty-eight males and 48 females repeated either the test word (experimental) or a nonsense syllable (control) under different speeds and durations for semantic satiation in a "posttest only" design, with no pre-repetition word associations or semantic differential ratings. No experimental satiation was noted in number of associations and frequency of first associate, and experimental generation was surprisingly found in semantic ratings.

There are two types of semantic satiation, connotative and associative (Amster, 1964). In the first case, satiation is determined by lower semantic differential ratings after repetition, and in the second case, which is of main interest here, by decreased number and lower commonality of word associations to the repeated word. Kanungo & Lambert (1963) found no decrease in total number of associations although less relevant responses were noted, and Smith & Raygor (1956) also reported less common associates following visual self-satiation. On the other hand, Fillenbaum (1963, Experiments I-IV) found no difference between experimental and control conditions, except in Experiment V where experimental Ss gave more common associations than control after a short 4-sec. repetition treatment.

The present experiment is a parametric study designed to discover the specific conditions for satiation or even generation effects, especially possible interactions among variables commonly manipulated in semantic satiation studies (duration and rate of repetition) as well as factors rarely examined (sex and association strength of test words), and the relations between several indices of semantic satiation.

Method

Ss were 48 male and 48 female undergraduates drawn from UCLA introductory psychology courses.

Six monosyllabic nouns, the test words, were taken from the Palermo & Jenkins (1964) word association norms for 1000 college students. The three high association words, BOY, DOG, LAMP, each evoked one association 70.4%, 67.9% and 70.6%, respectively. Rates for the three low association words, CARS, CHEESE, MOON, were 10.7%, 10.6% and 21.6%, respectively. The six nonsense syllables were VAY, NUR, TEB, ZEM, PAJ and KUD. The three generation scales (large-small, fast-slow, wide-narrow) and three satiation scales (beautiful-ugly, active-passive, good-bad) were the same used by Yelen & Schulz (1963, Experiment IV).

Each male and female S was randomly assigned to one of eight treatments. S first was trained to match the

repetition rate of an electric metronome set at either 1 or 3 beats per second. Then S repeated the first of either six test words or six nonsense syllables for either 5 or 15 sec. Immediately after repetition, S wrote as many associations as possible to the test word in 1 min., followed by rating of the test word on the six semantic differential scales. A 30-sec. interval during which the metronome was on at the appropriate rate preceded the next repetition period. So the sequence was repetition, word association, semantic rating, 30-sec. "refresher" repetition training with metronome, repetition, word association, and so on. In sum, a 2⁵ factorial design was used: males vs. female; experimental test word vs. control nonsense syllable repetition; fast vs. slow rate; 5 vs. 15 sec. duration; and high vs. low association test words (a repeated measure).

The stimuli to be repeated were presented on 3x5 cards, said out loud once, removed, then repeated at the given rate and duration. In each group, order of words or nonsense syllables was counterbalanced.

Number of associations was obtained by adding the number of different associations written for each test word. Frequency of the first association was checked using the Palermo & Jenkins norms. The most common response was given a score of 1 down to 5 for the fifth most common, and 6 for any other associate. Polarity scoring of semantic scales was used, with the midpoint of the 7-point scale as 0, and moving from 1 to 2 to 3 from the midpoint to either extreme. Semantic satiation would be reflected in smaller number of associations, less common first associates, and more neutral or lower scale ratings.

Results and Discussion

Analysis of variance was carried out for all three dependent variables. No significant differences between experimental and control in associative satiation resulted, but the experimental group displayed significantly higher semantic ratings than the control group ($p < .05$), and this result indicated generation. High association words showed significantly lower number of associations, more common first associates, and lower semantic ratings. Females gave significantly higher semantic ratings than males. Fast repetition evoked significantly greater number of associations than slow. None of the interactions were significant, except for one three-way and one four-way interaction in number of associations, both uninterpretable.

Schulz, Weaver, & Radtke (1965) reported no connotative satiation when a "posttest only" design, the same

used here, was presented, and the data here showed no evidence of associative satiation either. Perhaps the experimental effect was washed out by combining the 5-sec. duration (generation) and 15-sec. (satiation) conditions. Such a possibility might be noted in a Treatment by Duration interaction, but none was found across all three satiation indices. Another question may involve the intervention of the word association period between repetition and ratings, which could have dissipated any initial satiation. This might explain experimental and control groups giving similar ratings, but certainly not the control group showing significantly lower scores as was found. The result is consistent with Schulz et al's trend for lower polarity in their control groups.

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Note

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Double alternation in children's binary choice responses¹

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The presence of significant amounts of double alternation in a 70:30 binary choice problem is demonstrated among first-grade children as a function of positive reinforcement and of instructions that stress only correct responses.

The presence of single (side-to-side) alternation and of relatively stereotyped responses to one lever has been noted frequently in various kinds of learning experiments, and several models exist for understanding these phenomena (Dember & Fowler, 1958; Skinner, 1942; Tune, 1964). The present experiment indicates the presence of a substantial amount of double alternation in a two-choice probability-learning experiment, resulting from the valence of reinforcement and instructional explicitness. The unanticipated presence of double alternation is of interest both because it has not been previously reported in such learning situations, and because it poses peculiar problems for theories of learning and arousal that attempt to account for behavior in the two-choice situation.

Method

Subjects. Ss were 64 first-grade children, equally divided among boys and girls. A female E conducted the experiment.

Apparatus. S's mechanism was a black box with two toggle automatic-return switches along the lower edge of the front panel. A buzzer located inside S's machine signaled him to make a response which was then transmitted to and recorded from a monitoring device.

Procedure. A 2 by 2 design was implemented in which the valence of reinforcement and explicitness of instructions were varied. In the positive-reinforcement-explicit condition (PRE) S was told "If you push the right button I'll say 'right.' If I don't say anything, it means that the button you pushed was wrong." For the negative-reinforcement-explicit condition (NRE) E said, "If you push the wrong button I'll tell you it's wrong. If I don't say anything, it means that the button you pushed was right." In the implicit conditions, E did not remark on the meaning of nonreinforcement. Thus, for the positive-reinforcement-implicit condition (PRI), E simply said, "If you push the right button I'll say 'right'," while for the negative-reinforcement-implicit (NRI) condition, E said, "If you push the wrong button, I'll say 'wrong'," adding no further remarks on the value of the right button. These instructions were rephrased and repeated several times.

Ss were reinforced on each of the 160 trials. Inter-trial interval was 2 sec. The reinforcement ratio was 70:30, randomly distributed in blocks of 20 trials. For

the PRE and PRI conditions, 70 percent of the left-hand responses and 30 percent of the right-hand responses were positively reinforced. For the NRE and NRI conditions, the reverse inputs were employed. Thus, responses to the left lever were correct more often for all experimental conditions.

Results

Choice Preference. The mean left lever responses over all trials ranged from 56 percent to 60 percent; for trials 101-160, it ranged from 58 percent to 62 percent. Analysis of variance indicated no differences in left lever responding as a function of either experimental condition ($F < 2$).

Response Patterns. In order for a response to qualify as either a single alternation (ABABA or BABAB), double alternation (AABBAA or BBAABB), or stereotyped response (AAAAA or BBBBB), it had to be preceded by four similar responses. The probabilities of such response sequences occurring were sufficiently low that one could safely term them patterns or strategies. A response was scored in one and only one category.

Three nonredundant scores were thus obtained: single alternation, double alternation, and perseveration. Close to 90 percent of the total responses consisted of some kind of patterned response to the task. Similar findings with regard to patterning have been reported by others (Gerjuoy & Gerjuoy, 1965; Tune, 1964).

Each pattern was subjected to a 2 by 2 analysis of variance. For single alternation and perseveration the analyses were computed on arcsin transformed data, and no effects were found (all F s < 2.00). Both valence of reinforcement ($F = 4.10$; $p < .05$) and instructional explicitness ($F = 6.28$; $p < .01$) affected the degree to which double alternation was present. As Fig. 1 indicates, the level of double alternation in the implicit instructions condition was consistent and high throughout all trials.

Discussion

The presence of double alternation responses constitutes something of a dilemma for various learning theories, since from these theories one would expect a tendency to repeat the reinforced response. This dilemma has, of course, been confronted previously in the context of single alternation (cf. Dember & Fowler, 1958; Tune, 1964). Consider Hull's (1943) reactive inhibition hypothesis. The tendency to respond to the left is presumed to be inhibited immediately after a left response, rendering a right response momentarily predominant. In the case of double alternation, however,

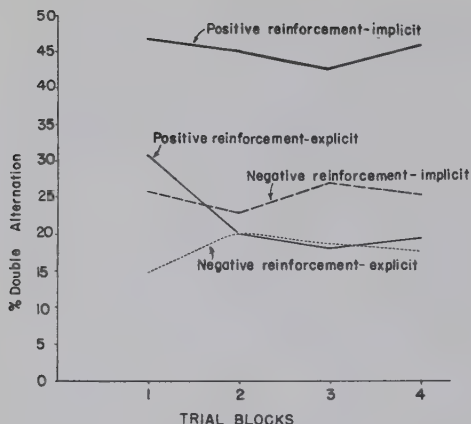


Fig. 1. Double alternation in blocks of 40 trials as a function of experimental condition.

the right response gains ascendancy only after two left responses, a phenomenon that cannot be accounted for by Ir. Similar arguments hold for Glanzer's (1953) stimulus satiation, Walker's (1956) action decrement, and Jarvik's (1951) negative recency effects. Skinner's (1942) notion that response alternations reflect subjective perceptions of chance may be applicable here, but they do not directly account for why S's expectations should take this particularly symmetrical form, nor why they should be associated with specific conditions of information and reinforcement under asymmetrical conditions of reinforcement.

We have no ready and supportable explanation of double alternation. We are inclined to believe that double alternation is neither a problem-solving strategy, as these sequential dependencies are often labeled, nor is it associated with learning as such. Our belief is based on the fact that the levels of double alternation remained consistent throughout the experiment, showing none of the acquisition characteristics typically associated with learning. Moreover, we obtained evidence that our Ss learned the correct response even though their choice preferences and response patterns did not directly reflect it. In response to the post-experimental question "Which was the best button?" all but two of the 64 Ss pointed to the left lever (and the two who were not certain appeared to manifest no special pattern of

responding). Thus, we apparently obtained "awareness without learning."

The failure of this sample to match, let alone maximize, the input probabilities is consistent with findings reported by Kessen & Kessen (1961) and Weir (1964) for children of this age. However, even among young children, where the incentive value of being praised is high (and being told by an adult E that one's response is right can be interpreted as praise by a young child), matching and even maximizing can occur. Thus, lower-class children, for whom reinforcers from a middle-class E are presumed to have high incentive value, will match or exceed input probabilities (Rosenhan, in press).

Second, the incidence of single alternation among these Ss is also noteworthy. Averaging 45 percent of all responses, it is consistent with findings reported previously (Gerjuoy & Gerjuoy, 1965; Weir, 1964).

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Note

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Test of a theory of predictive behavior in young children

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Data are presented in support of a theory of predictive behavior in young children which emphasizes the role of attention and response- and event-produced stimulus traces, and deemphasizes the role of learning in the prediction of binary event sequences by young children.

In the binary prediction situation, S's task is to predict which of two events will occur on each of a series of trials by making one of two predictive responses (PR) each time a cue occurs. When preschool children predict the next event in a single alternation sequence they almost all make errors. They do not always pay attention to the events they have just predicted, in that during the interval in which the event occurs they may be looking away and not see it. Such inattending often coincides with an error run in which the events alternate ABAB... while the child is predicting BABA... on the same trials. Apparently at times the child simply alternates his previous PR regardless of the event. Termination of such a run of errors is often preceded by a reorientation to the event during the final error trial, accompanied by a verbal or nonverbal response which suggests S has noticed he made an error. Errors also occur on trials in which the child takes a long time to predict, appears indecisive, and considers aloud the two alternatives before responding, suggesting that at times the PR's are guesses.

Theory

Assume that each PR produces a stimulus trace, t_r , conditioned to the alternate PR, and that if t_r is still present when the cue for the next PR occurs, it elicits that alternate PR. Assume that if S makes an attending response (AR) to the event, the t_r is displaced by a trace of the event, t_e , and that if t_e is still present when the next cue occurs, it elicits the PR to which it is conditioned, prediction of the alternate event. Also assume that t_r and t_e are vulnerable to distracting stimuli which displace them, and that if no trace is present when the cue occurs, S guesses at random. (The conditioning states of the traces, i. e., the rules determining which response a given trace will elicit, are taken to be determined by

preexperimental associations, associations established during pretraining sessions, or learning which is completed during the early trials of the experiment.) In everyday language, the assumptions say that on each trial S guesses at random unless he remembers his previous PR or the event just presented. If he remembers the PR, he makes the alternate PR; if he remembers the event, he predicts the alternate event. To remember the event he must have paid attention, and if he remembers the event he does not remember his response.

If now it is also assumed that on each trial the probability of an AR is p , the probability of displacement of t_r by distracting stimuli is d_1 , and the probability of displacement of t_e by distracting stimuli if the AR does occur is d_2 , then the stochastic process and its associated probability measure shown in Fig. 1 describes the trial-to-trial response transitions. Recalling that the sequence of events is a single alternation sequence, it immediately follows that the sequence of correct responses and errors will be a two-state first order Markov chain with stationary transition probabilities. The entries in the transition matrix of this chain will be $p_{cc} = 1 - \frac{1}{2}\gamma$, $p_{ce} = \frac{1}{2}\gamma$, $p_{ec} = \alpha + \frac{1}{2}\gamma$, and $p_{ee} = \beta + \frac{1}{2}\gamma$, where p_{ij} is the probability of a transition from a response of type i on trial n to a response of type j on trial $n+1$, and where $\alpha = p(1 - d_1)$, $\beta = (1 - p)(1 - d_1)$, and $\gamma = 1 - \alpha - \beta$. Obtaining maximum likelihood estimates of α and β , and therefore of γ (Anderson & Goodman, 1957), and also an estimate of the initial probability of a correct response, it is possible to predict the values of various sequential statistics both for the group data and for individual Ss (Bogartz, in press).

Method

Twenty 4- and 5-year-old children from the University Preschool Laboratories predicted on 100 consecutive trials the color of the next marble in an alternating sequence of two colors randomly selected from the colors Black, Blue, White, and Yellow. Each S was seated before a marble-dispensing apparatus and told that he was going to play a marble game. He was instructed to guess the color of the next marble each time the buzzer sounded and to press the marble-release switch only after making his guess. He was shown a pair of marbles having the colors which would be presented and asked to identify their colors. Then S was told that that pair of colors would be used in the game but that first he would practice with red marbles. Five practice trials were given in which S predicted the red marble each time the buzzer sounded and then obtained a red marble by pressing the switch. The S was again shown the two colors and reminded that only they would occur. The 100 trials were then run without interruption, with the buzzer sounding for .3 sec. every 8 sec.

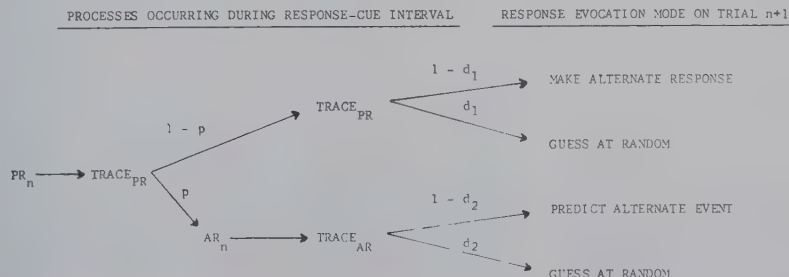


Fig. 1. The stochastic process and probability measure characterizing the trial-to-trial response transitions.

Table 1. Comparison of observed relative frequencies of 3-tuples with relative frequencies predicted using the same parameter values for all Ss.

	ccc	cce	cec	cee	ecc	ece	eec	eee
Pred.	.536	.113	.091	.045	.119	.025	.047	.023
Obs.	.560	.096	.095	.042	.097	.041	.042	.027

Results

A χ^2 -test of homogeneity of parameter values within the group of 20 Ss gave a χ^2 of 171.93 on 38 df, equivalent to a z of 9.88. The individual sequences, therefore, almost certainly are not samples from the same first order Markov chain, consequently group χ^2 -tests of Order and Stationarity are of little value since they presuppose samples from a single chain. There is interest, nevertheless, in the extent to which the model implied by the theory described above predicts the group data even when there is heterogeneity of parameter values. Table 1 shows the observed relative frequencies with which the eight possible 3-tuples occurred throughout the 20 100-trial protocols. The predicted values were obtained using a single parameter set for the entire group. Apparently the group data are predicted well even when the parameter values vary among the individual Ss.

Table 2 and Fig. 2 show that the model is predicting well the behavior of the individual Ss. Table 2 shows that averaging over the individual predicted values obtained by estimating a parameter set for each S results in smaller deviations of predicted values from the observed group means for the 10 sequential statistics than does predicting on the basis of a single parameter set. This is true also for the total number of runs of errors for which the observed mean value was 13.95, Pred_G was 14.44, and Pred_A was 13.74.

Figure 2 shows the scatterplot of observed vs. predicted total number of error runs for the 20 Ss, indicating that the result in Table 2 is not due to cancellation of large but opposite discrepancies for the individual Ss. Inspection of the observed and predicted values of r_j and C_k for the individual Ss revealed goodness-of-fit comparable to that shown in Fig. 2.

Discussion

The results provide substantial support in general for

Table 2. Observed and predicted mean values of r_j , the number of error runs of length j , and C_k , the number of joint occurrences of two correct responses k trials apart, with Pred_G obtained by using one set of parameters for the entire group, and Pred_A obtained by averaging over individual Ss the predicted values obtained with individual parameter estimates.

	Pred_G	Pred_A	Obs.		Pred_G	Pred_A	Obs.
r_1	9.72	9.39	9.80	C_1	64.27	65.02	64.80
r_2	3.18	2.73	2.25	C_2	61.52	63.23	64.20
r_3	1.04	.95	1.30	C_3	60.56	62.34	61.50
r_4	.34	.37	.45	C_4	59.88	61.63	62.15
r_5	.11	.16	.15	C_5	59.24	60.96	60.20

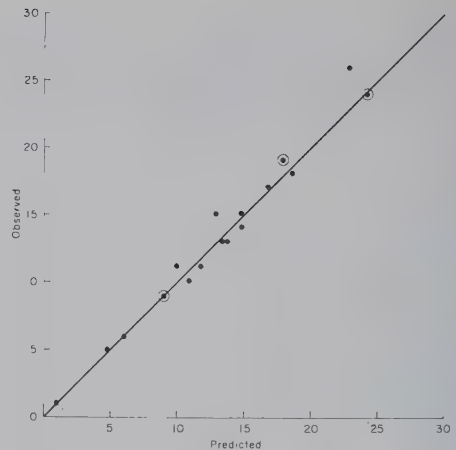


Fig. 2. Scatterplot of the observed vs. predicted total number of error runs for the 20 Ss.

the class of theories which imply a two-state first order Markov chain with stationary transition probabilities as a model of the sequence of correct responses and errors, and in particular for the theory described above. The latter, which views the child as a system that generates its output by tracking either the PR or the event on the previous trial or by switching to a random output generator when off track, provides an alternative to learning theories which thus far have swept the field with respect to theoretical formulations of performance changes in the binary prediction situation. The present theory predicts a mean performance curve which is of the same exponential form as that arising in a number of learning models (e.g., Estes, 1959), although it focuses not on trial-to-trial changes in the conditioning states of the stimulus or stimuli, but rather on trial-to-trial changes in the source and type of stimulus which elicits the PR. This theory does provide a role for early, rapid conditioning of the stimulus traces, and of course would require their reconditioning to explain performance changes which would follow transfer to a new type of sequence. The questions which will be at issue if the present theory is shown to have generality will be when and how fast does learning take place, and must it be assumed to be occurring throughout the entire session in the binary prediction situation, or will other mechanisms be more appropriate to the explanation of most of the trial-to-trial changes in behavior.

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The effect of experimental manipulation on cooperative behavior in a chicken game¹

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Forty male and 40 female undergraduates participated in a mixed-motive game. For the first 50 trials, a simulated "other player" used a tit-for-tat strategy which reciprocated the S's choices with a one-trial lag. Ss who received the same choice from the "other" on the first trial became significantly more cooperative in the next 50 trials than Ss who received a different choice. A second phase explored some experimental treatments which were designed to change the degree of cooperation or competition shown by the S, and demonstrated significant effects in the predicted direction.

A number of investigations have failed to produce any marked effect on S's game behavior by systematically varying information about the other player's behavior (Gallo & McClintock, 1965; Sermat, 1964). The present study investigated two problems: (1) the relationship of S's first choice and the first choice of a simulated "other" to S's subsequent game behavior, and (2) the effectiveness of a flexible treatment program, in which an experienced experimenter assumes the role of the other player, to produce changes in the strategy employed by S.

Method

The Ss were 40 males and 40 females from introductory psychology courses at the University of Oregon. Four Ss of the same sex, separated by opaque screens, participated simultaneously. In front of each S was a panel displaying the payoff matrix and two black and two red pushbuttons, arranged as shown in Fig. 1. This type of game yields the lowest payoff when both participants choose the competitive (red) alternative, and is known as the game of "Chicken." Each S was told that he would be paired with one of the other three individuals present, that their choices would jointly determine their payoffs as shown in the matrix, and that each S was to attempt to make as many points as possible for himself.

Three males and two females served as experimenters. In each experimental session, two E's were present, but only one was seen by the Ss. Each E served as the visible experimenter for 8 male and 8 female Ss. During the experiment, each of the two E's present gave payoff information to two of the Ss, as follows.

During trials 1-50, the alleged "other player" made whatever choice S had made on the immediately preceding trial (the 'tit-for-tat' strategy), except for the first trial, where the "other's" choice was determined by tossing a coin. At the end of the first 50-

		"CHICKEN" MATRIX	
PERSON "B"	RED	A = 3 B = 10	A = 1 B = 1
	BLACK	A = 8 B = 8	A = 10 B = 3
		BLACK	RED
		PERSON "A"	

Fig. 1. The payoff matrix.

trial session, E classified as "cooperators" those Ss who had made 4 or fewer red choices in the last 20 trials, and as "competitors" those Ss who had made 5 or more red choices.

For trials 51-100, E continued to treat the "cooperating" Ss with a general tit-for-tat strategy, except that the S was given two more red choices from the "other" in each 10-trial block than would have been required by the S's own preceding choice sequence. If the S had been classified as a "competitor," E was required to use whatever strategy he judged as ap-

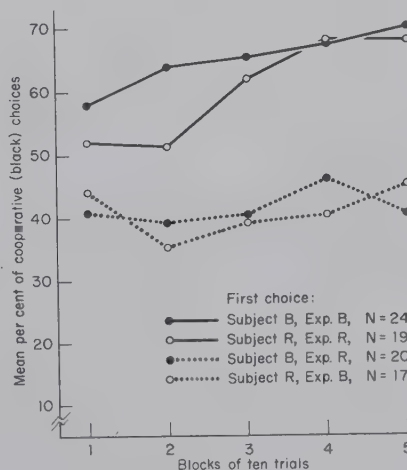


Fig. 2. Mean per cent of cooperative choices by subjects who received either the same (BB,RR) or different (BR,RB) choice on first trial.

propriate in order to make the S more cooperative. After trial 100, Ss were once more classified as "cooperators" or "competitors" on the basis of their performance in trials 81-100, and the same rules for treatment were used.

Results

Trials 1-50. It is apparent from Fig. 2 that Ss whose first choice coincided with that of the simulated "other player" made a higher number of cooperative choices than did Ss whose first move differed from that of the simulated "other." Among same-choice Ss, 18 made 50 per cent or fewer black choices on trials 1-50 and 25 made more than 50 per cent black choices; for different-choice Ss the corresponding frequencies were 29 and 8 respectively. The resulting Chi-square of 11.1 is significant at the .005 level.

Trials 51-150. Figure 3 shows the treatment effects on cooperation during the second phase of the experiment. Of 67 Ss who made fewer than 80 per cent of cooperative choices in trials 81-100 and were subsequently given individually designed treatments to make them more cooperative, 45 became more cooperative, 17 became less cooperative, and five did not change (sign test $p < .005$). Of the 13 Ss who made 80 per cent or more cooperative choices in trials 81-100 and who were subsequently given at least 20 per cent competitive choices by the "other," 10 became more competitive, 2 more cooperative, and one did not change (sign test $p < .025$).

Discussion

The results show that whether the "other's" choice is the same or different from S, is crucial. Mutual cooperation on the first trial rewarded the S with a relatively high payoff of 8 points, while mutual competition punished him with the lowest possible payoff of 1 point. Both of these outcomes are likely to strengthen the tendency to choose cooperatively. On the other hand, different choices are likely to strengthen the competitive tendency. When the S chose red while the "other" chose black, S was rewarded for competition with both the highest payoff (10 points) and a differential gain over the other player. When the S chose black while the "other" chose red, S was punished for cooperation with both a low payoff (3 points) and a differential loss.

In previous research (Sermat, 1964; Sermat, 1966), fixed treatments, uniformly administered to all Ss throughout the experiment, had only limited success in

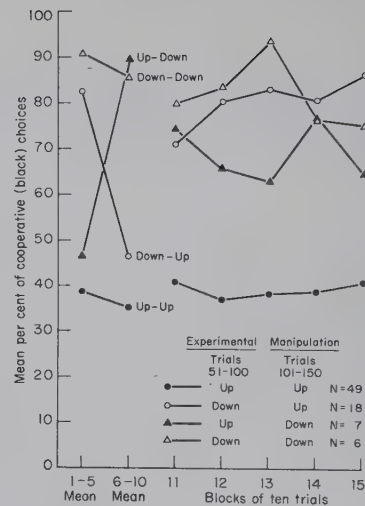


Fig. 3. Mean per cent of cooperative choices by subjects who were manipulated to become either more cooperative ("up") or more competitive ("down").

inducing cooperation. For this reason, "competitive" Ss were given a flexible treatment, adapted to the S's own behavior, with the hope of increasing cooperative behavior. A significant increase in cooperation was found. However, Fig. 3 reveals that while a minority of competitive Ss became highly cooperative during trials 51-100, the large majority of competitive Ss became only slightly more cooperative as a result of 100 trials of experimental manipulation. On the other hand, even the small amount of competitive exploitation used in the present study reduced cooperative behavior in the majority of cooperative Ss.

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